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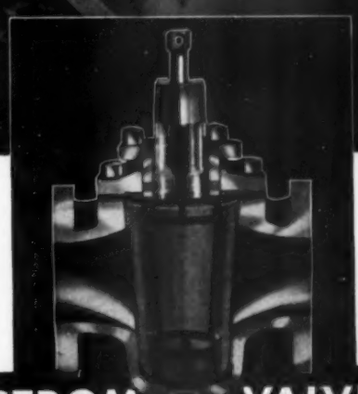

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April 29, 1941

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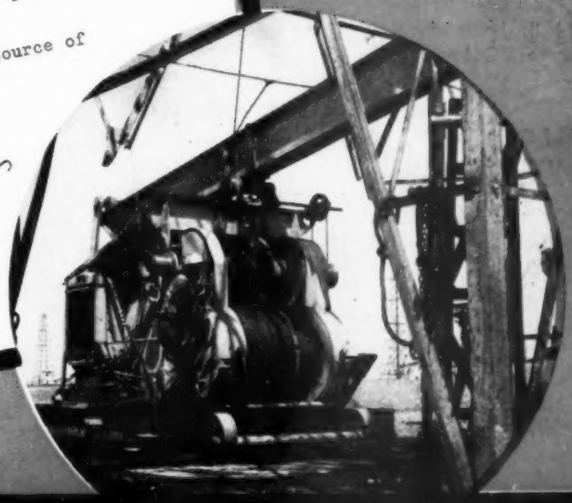

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November, 1941

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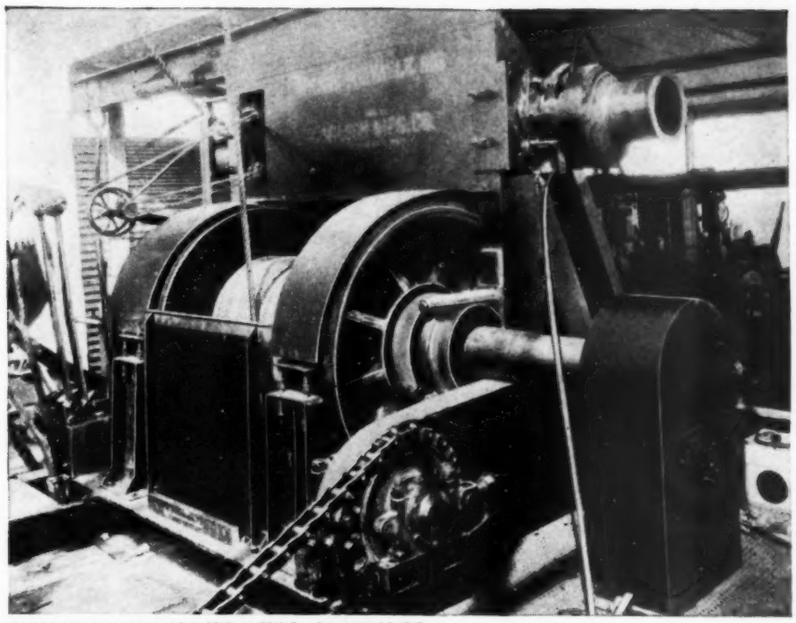

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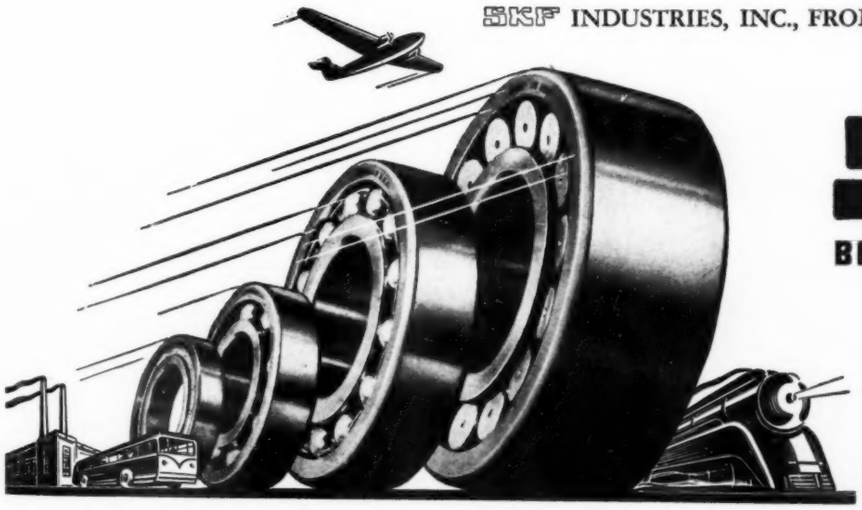

SKF

BALL & ROLLER BEARINGS

The Course of Oil

by K. C. SCLATER

After Twenty-one Years

Petroleum is widely distributed throughout the world, and I believe, in sufficient quantities to meet the requirements, present and future, and if the economic law of supply and demand is given a free opportunity to assert itself, artificial, political and governmental restrictions are removed, allowing everybody from everywhere to participate in the prospecting and production necessary, there will be plenty of oil to meet the requirements in all parts of the world for many generations to come.

There have always been frequent and loud predictions that the source of supply was exhausted and there never again would be sufficient oil to supply the demand. In every instance these predictions have been wrong.

One of the troubles of the world, as I see it, during the last two years is too much government everywhere. Too many doctors, too much preaching and too little attention to the practical experiences of the past, too much intellectual energy involving all kinds of visionary schemes for governmental effort to improve the conditions of humanity, all of which would probably be all right if it were not for the fact that humanity is what it is.

Agitation by government officials, statesmen or politicians is just as dangerous as governmental regulation and interference. It destroys stability, credit and confidence as to the future. There is nothing we produce that needs the incentive of visions of wealth and the stability of property rights to a greater extent than petroleum. It is often said that nobody but an optimist continues to drill wildcat wells. His chances of failure are great enough without adding the uncertainties of governmental interferences. The petroleum industry of the world needs no special legislation involving governmental restrictions or regulations.

Resolutions have been offered in the United States Senate to investigate our business methods and prices. We have had an Assistant Attorney General trying to secure evidence to prosecute us.

Nothing is so destructive of development as such agitation. It taxes the vitality and the resources of the men who should be devoting all their talent along productive lines rather than combating attacks.

There has been a great deal of agitation in the United States in the name of conservation for State and National regulation to prevent waste; there have been many ridiculous statements made by men connected with government departments and other scientists as to the enormous waste which has occurred in the petroleum industry because of the lack of regulation.

Exaggerated statements and agitation along this line are not in the interest of oil conservation and the development of the petroleum industry for the people of this country.

I have always resented the statements that the development of the petroleum industry of America has been unnecessarily wasteful. I do not think that the petroleum industry, as a whole, has anything to apologize for along this line. I do not believe any development in the history of the world of its natural resources has been of greater importance to the welfare of humanity than the sixty years of active development of the petroleum resources of this country.

There is no doubt practical economic development and use of our petroleum resources will bring about increased economy and usefulness and the thoughts of thousands engaged in the business and conscientious study of the problems by scientists will bring about improvement as it has in the past.

A man does not have to be a scientist to point out errors of the past comparing them with the now known methods and asserting that unnecessary waste would not have occurred if modern equipment and knowledge had been available.

As Americans, stop apologizing for the petroleum industry in the name of conservation. Continue to conserve and develop as we have along proper economic lines and the great good for all the people will then be accomplished.

In conclusion, let me say I have no apprehension as to the future petroleum supply of either this country or the world at large, and the danger now confronting us, which is really serious, is not caused by exhaustion, but is likely to occur through the foolishness of men in permitting restrictions caused by too much government.

We ask for no financial assistance by our government except to use all proper means to stabilize and protect property rights where honestly acquired. The petroleum industry of this country has the necessary talent, energy, resources and will to take an active part in the development of this very essential product.

At home, for a healthy full development, the petroleum industry needs a friendly, fair and coöperative spirit on the part of our governmental departments. It needs a fair and just public opinion. On its part, it must conduct itself in a conservative and proper manner, obey the spirit as well as the letter of the general laws regulating our industrial life. It must give the public a square deal. If the American Petroleum Institute can assist in bringing this about it will perform a public service in the interest of all the people as well as of the petroleum industry.

The foregoing are excerpts from an address delivered twenty-one years ago at the Annual Meeting of the American Petroleum Institute, by Thomas A. O'Donnell, the first President of the Institute. Even after twenty-one years of vast achievement and progress, the remarks of Mr. O'Donnell to the petroleum industry are applicable today.

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Highlights IN OILDOM

Conference on Contract Drilling Costs

Dale H. Flagg, of the Chief Counsel's Office, and D. W. Williams, both associated with the Minerals Division of the Department of Internal Revenue, presided at the conference held in Washington on November 3 to discuss the rumored changes in procedure involving the capitalization of contract drilling costs and the proper interpretation of Section 19.23(m)-16 of Income Tax Regulations 103. The conference was requested by J. E. Brantly, president of the American Association of Oilwell Drilling Contractors, and other interested parties in the oil industry were invited to attend the conference. The Office of the Coördinator of Petroleum for National Defense was represented by Robert Allen, director of production in the coördinator's office.

The Commissioner of Internal Revenue ruling to the effect that the cost of drilling wells by footage contract, of the type now widely used in the oil industry, must be capitalized rather than deducted from income as intangible drilling, was discussed.

Confidential instructions were recently sent out, the purport of which is that operators will not be permitted any longer to expense the amount paid to contractors for clearing the land and drilling the well if the contractor takes any of the risk. The recent Board of Tax Appeals decisions in the *Retsal* case (42 B.T.A. 1057) and the *Ambrose* case (42 B.T.A. 1405) occasioned the instructions and the Bureau representatives expressed themselves as willing to accept some workable solution to the problem if one could be found.

It was indicated that the matter will be held in abeyance, so far as possible and as long as possible. There was some indication that legislative relief might be necessary. Bureau representatives expressed themselves as being sympathetic and as aware entirely of the burdensome nature of the propos d instructions, but they also expressed themselves as powerless to effect any change unless some brief on the law points involved could show a solution.

Those attending the conference were invited to submit briefs on the point, these briefs to be submitted on or before November 14.

New Refining Method

A new refining process that removes obnoxious odor from gasoline and increases its octane rating has been announced by Robert H. Colley, president of Atlantic Refining Company, Philadelphia, Pennsylvania. The process, said to be an inexpensive operation using caustic soda and methanol, was developed after ten years' experimentation by Atlantic chemists. It will be licensed to other refiners, Colley says.

The new refining method removes from gasoline virtually all sulphur, the element responsible for the bad odor. After the sulphur and its compounds are removed, the amount of tetraethyl lead required for the production of antiknock, high-compression motor fuel is considerably reduced, according to Colley.

Urge Better Priority Classification For Petroleum Industry

The three general priority classifications under which the petroleum industry is operating are "inadaptable and inadequate," says a report by a sub-committee of the production committee of District 2 in a report to Frank O. Prior, chairman of the sub-committee on equipment materials and supplies of the production committee.

The report urges a special classification for the petroleum industry with a rating not lower than A-3 instead of the general classifications U-22, P-6, and FD-1.

"Unless a much higher preference rating is made available to the oil industry, a gradual deterioration of plants and operating equipment is sure to develop," the report said. "It is certain that the priorities division would not risk such deterioration if it were aware of the development.

"Preference rating order P-22 gives the same consideration to manufacturers of juke boxes, paper clips, pool tables, etc., as is accorded the petroleum industry upon which the whole defense program depends."

Petroleum Industry's Steel Needs for 1942

The petroleum industry will require 5,846,000 tons of steel to operate in 1942 on a scale calculated to meet all demands of the defense program, the office of the petroleum coördinator has estimated. The forecast was made for the office of production management in making steel allocations for next year.

Under present emergency conditions, the petroleum office said, only the construction, transportation, and machinery industries outrank the oil business in steel requirements. In normal times, transportation, including the rail and automobile industries, is the biggest consumer of this metal, with oil next.

The 1942 requirements of each branch of the petroleum industry were estimated as follows: production (on the basis of more than 30,000 wells) 3,175,000 tons; transportation (for pipe lines, tank cars, tank trucks) 1,843,000; refining (including aviation gasoline facilities) 647,000, and marketing 181,000.

The production branch of the oil industry is the nation's biggest user of metal pipe.

Michigan May Get Wider Spacing Units

P. J. Hoffmaster, Michigan state supervisor of wells, and the Michigan oil advisory board, are considering wider spacing units. The units under consideration are 40 acres for the Basin area and 20 acres for the southwest area. The proposal will be considered further at a meeting later in the month, Hoffmaster said. The proposal, he stated, is being considered both as a conservation and as a material saving measure. If adopted, the ruling is expected to apply to wildcat drillings and to all future pools.

Henderson Requests No Further Price Advances

Price Administrator Leon Henderson on November 7 requested crude oil producers, refiners, and marketers to refrain from further price advances.

Henderson sent telegrams to all principal producers and purchasers of crude oil asking them to hold purchase prices to the level prevailing on October 1. The step, he announced, would formalize the relationship between the companies and the Office of Price Administration.

Letters were sent to the larger marketers of gasoline and other refined products asking them to make no price advances in petroleum or petroleum products without prior notice and approval by OPA.

These instructions cover gasoline, kerosine, burner oil, heavy fuel oil, lubricating oil, and other petroleum products.

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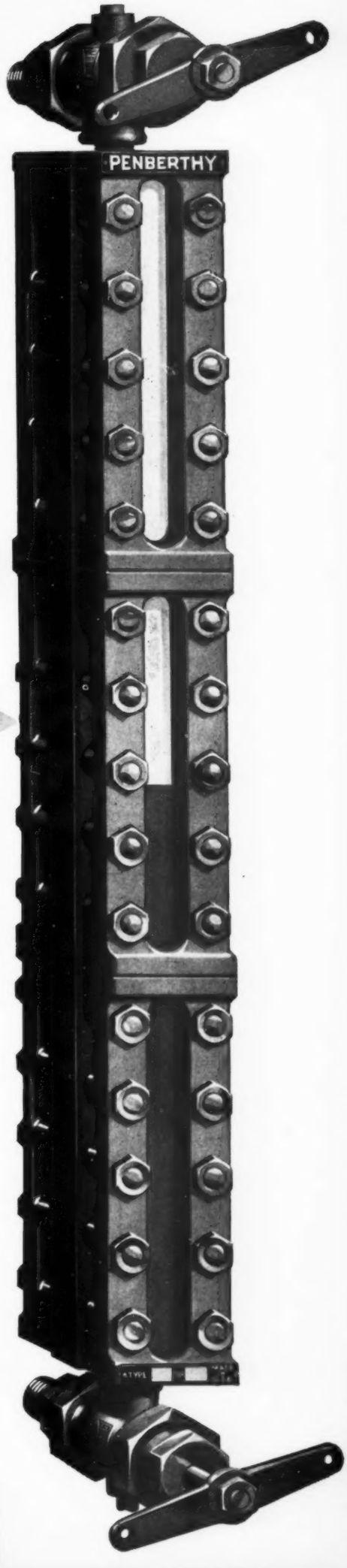


MAJOR *Refining* ACTIVITIES

Percent Refining Capacity Operated

Western Division, 82.6 Percent Central Division, 88.4 Percent Eastern Division, 101.2 Percent

VICE-PRESIDENT H. W. Harts, of the Warren Petroleum Corporation, Tulsa, Oklahoma, has announced the beginning of construction on its plant No. 22, 4 miles north of Aylesworth, in the Cumberland field of Marshall and Bryan counties, southern Oklahoma.

Natural gas from the wells of the Pure Oil Company in that area will be processed. These wells are in the area that will be floooded when the Red River-Denison dam is completed and the reservoir, forming part of the land now served by the Red River and Washita River, is filled. This will occur in 1945 or 1946 at which time the leases from which the gas is to be obtained will be completely submerged and all field lines will be elevated on a trestle system before the permanent flooding of the area takes place.

The new plant will be equipped with nine 200-hp. compressors operating on 5-in. vacuum intake and will discharge at 300-lb. pressure. The fractionation equipment will include a deëthanizer, a depropanizer, a debutanizer, and a de*iso*butanizer. Plant production will be 6000 gal. per day of propane, 3500 gal. of *iso*butane, and 18,000 gal. of 26-70 grade natural gasoline from approximately 8,000,000 cu. ft. of gas per day. Oil circulation of 150 gal. per min. at 300-lb. pressure will be maintained on the high-pressure absorber.

An announcement has been made by Howard A. Cowden, president of the Coöperative Refinery Association, a subsidiary of the Consumers Coöperative Association, North Kansas City, Missouri, that the association has purchased the 1500-bbl. oil refinery of Terry Carpenter, Inc., Scottsbluff, Nebraska.

Cowden said the purchase price of the property was approximately $750,000 with the transfer of property to become effective December 2.

A 3400-bbl. refinery at Phillipsburg, Kansas, is now being operated by the Coöperative Refinery Association and the addition of the Scottsbluff plant will permit the association to produce between 60 and 70 percent of the total refined fuel needs of its members.

The Consumers Coöperative operates in Nebraska, Kansas, Missouri, North and South Dakota, Colorado, Wyoming, Oklahoma, Iowa, and Utah.

Geier and Jackson, Dallas, Texas, have submitted a request to the Texas Railroad Commission for permission to build an absorption type cycling plant of 50,000,000 ft. of gas per day capacity to be operated in the Grapeland field, Houston County. A distillate type plant is being operated in the field by Geier and Jackson at present.

The Standard Oil Company of California is considering construction of a lubricating-oil plant at the Richmond refinery on San Francisco Bay for the production of high-grade aviation lubricants in greater coöperation with the national defense program.

Expected to cost about $5,000,000, erection of the plant depends upon the company's obtaining the necessary priorities for materials.

Construction will begin in about 3 months on the Gulf Oil Corporation's aviation gasoline unit at the Port Arthur, Texas, refinery. The unit will have a capacity of 2500 bbl. per day.

To cost more than $1,000,000, the unit will include a Houdry catalytic cracking unit to produce base stock with an *iso*octane plant for alkylate production for blending the stock into 100-octane gasoline. Addition of the new unit will increase output of aviation gasoline at the plant from 1500 to 4000 bbl. per day.

A natural gasoline plant and compressor station in eastern Moore County, Texas, will be placed in operation about January 1 by the Texoma Natural Gas Company. The plant is now half finished. Construction work is being directed by J. G. Barnhart of Amarillo, Texas, chief engineer for the Texoma Natural Gas Company.

The Humble Oil and Refining Company requested permission at a recent hearing of the Texas Railroad Commission for the construction of a 200,000,000 ft. per day gas cycling plant in the Katy field, Waller County, Texas. The plant will be one of the largest absorption type plants in the state, it is stated. It will begin injections to 2 wells and then later to 4 more.

Eleven gas wells are to be tied into the plant at first and 4 more later.

Sonken-Galamba Company, Kansas City and Tulsa, which recently purchased at federal receiver sale all assets of the Falcon Refining Company at Great Bend, Kansas, announces that a new firm has been organized to rehabilitate and operate the plant as the Plains Oil and Gas Company. Present skimming capacity of the plant is 1500 bbl. per day and will be increased to 3500 bbl. per day by the addition of a cracking unit and additional processing equipment.

Crude Runs to Stills, Gasoline, Gas, and Fuel Oil Stocks
Week Ended November 1, 1941
A.P.I. Figures
(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	655	97.3	19,220	33,233
Appalachian	83.8	146	105.0	3,292	1,077
Ind., Ill., Ky.	84.4	664	104.6	15,639	10,581
Okla., Kans., Mo.	80.7	310	93.1	7,576	4,398
Inland Texas	63.2	139	83.7	2,342	1,896
Texas Gulf	91.0	939	94.0	11,021	15,351
Louisiana Gulf	94.2	159	107.4	2,593	3,713
N. La. and Ark.	49.9	51	108.5	393	869
Rocky Mountain	50.1	45	66.2	996	427
California	90.9	602	84.2	14,751	75,923
Reported	86.4	3,710	94.6	77,823	147,468
Estimated Unreported	.....	370	.....	5,400	2,825
*EST'D TOTAL U. S. NOV. 1, 1941	.....	4,080	.....	(a)83,223	149,293
*EST'D TOTAL U. S. OCT. 25, 1941	.....	4,060	.....	83,343	148,478
U. S. B. of M. *NOV. 1, 1940	.....	**3,529	.....	79,185	156,048

*Estimated Bureau of Mines' basis.
**October, 1940, daily average.
(a)Finished 75,683,000 bbl.; unfinished 7,540,000 bbl.

HORTONSPHEROIDS

. . key to natural gasoline conservation

It is a proven fact that natural gasolines with high vapor pressures cannot be stored in ordinary tanks without excessive evaporation losses. Equally well-known is the fact that pressure storage provides a most economical and satisfactory method for storing these and other volatile petroleum products. These facts are self-evident when the underlying principle of pressure storage is analyzed. Here's how it works:

A volatile liquid in storage will boil when the surface reaches the temperature at which the vapor pressure is equal to the pressure acting upon the liquid. It follows that the boiling temperature can be raised by increasing the vapor space pressure. If the container is capable of withstanding pressure, boiling will continue only until the pressure in the vapor space becomes equal to the vapor pressure of the liquid. At this point boiling will cease.

Thus Hortonspheroids, because they are built to withstand internal pressure and are equipped with relief vents which are set to open at a pressure *above* that of the maximum vapor pressures resulting from normal temperatures, are capable of preventing vapor losses from natural gasoline in standing storage.

The three Hortonspheroids shown above have a combined capacity of 120,000 bbls., and are utilized for natural gasoline storage. All three units are designed for 20 lbs. per sq. in. pressure.

CHICAGO BRIDGE & IRON COMPANY

HOUSTON . . . . . 5637 Clinton Drive
TULSA . . . . . 1634 Hunt Bldg.
BIRMINGHAM . . . . . 1570 N. 50th Street
HAVANA . . . . . 402 Edificio Abreu

CHICAGO . . . . . 2481 McCormick Bldg.
DETROIT . . . . . 1538 Lafayette Bldg.
CLEVELAND . . . 2251 Builder's Exchange
PHILADELPHIA . . . 1635-1700 Walnut St.

NEW YORK . . . 3373-165 Broadway Bldg.
WASHINGTON . . . 811 Washington Bldg.
SAN FRANCISCO . . . . 1064 Rialto Bldg.
LOS ANGELES . . . . 1446 Wm. Fox Bldg.

Fabricating Plants in BIRMINGHAM, CHICAGO and GREENVILLE, PA.

MAJOR *Oil Field* ACTIVITIES

MISSISSIPPI has a new field opened by the Magnolia Petroleum Company in Warren County. The wildcat well is 25 miles southwest of the Tinsley field with production coming from the Wilcox formation.

The well is J. H. Hall No. 1, section 29-17n-14e. It was washed and bailed-in to flow 5 bbl. per hr. of half wash water and half 16.8 gravity, heavy asphaltic oil with no pressures reported, but gas was said to be light.

With the hole at a total depth of 2232 ft. and pipe set at 2193 ft. the operators had, at last report, gone back into the hole to bailout for a more complete test. The Wilcox was topped at 2198 ft.

Eddy County, New Mexico, has a new sand discovery 2¾ mi. north of the Grayburg pool. Nay Hightower Grier No. 1, 660 ft. from the northwest corner of section 31-16s-31e, gauged a natural flow of 173 bbl. of 37.4-gravity oil in 23 hr. through a 2-in. outlet off casing. This well logged the first sand from 3062-72 ft. and began heading oil. Deepening the hole brought an increase in oil and gas in a sand 10 ft. thick from 3108-18 ft. where the hole was bottomed. The well has been classed as a forerunner of a sand comparable to that of the Loco Hills field.

Stanolind Oil and Gas Company and associates have opened a new field in the Fred area of Tyler County, Texas. Production is from the Wilcox formation. Seventy percent oil and 30 percent wash water was reported flowing from the well through a 3/16-in. choke from 120 gun perforations in the area from 8180-8200 ft. The well, Parker No. 1, Collins survey, had a tubing pressure of 185 lb. and a casing pressure of 760 lb. Flow began after the operators had swabbed 8 times to clean the well.

Lackey No. 1, drilled by the Aladdin Petroleum Corporation in C. W. L. southwest southeast of 1-21-6w in Rice County, Kansas, is the 32nd new oil pool opened for the state. It is designated the Welch East pool. A potential of 278 bbl. of oil per day from the chat at 3366 ft. was recorded for the well. It is approximately a mile east of the Welch pool.

A new Smackover lime producing area in the Mount Holly section of Union County, Arkansas, has been brought into production by the Davis No. 1 unit, C NE NW, 15-17s-18w, after being perforated with 9 shots between 7166-68 ft. The well flowed 224 bbl. of oil and 5 bbl. of wash water through an 18/64-in. choke in 9 hr. The oil had a gravity of 38. Depth of the well is 7372 ft. with the location about 6 mi. east of the Village pool and 6 mi. northwest of the Shuler pool.

Illinois has two prospective new pools in Richland County and in Clay County. In Richland County, Nolf and others Nuding No. 1, wildcat well, in 6-4n-14w, was being completed on pump at last reports after swabbing 1000 bbl. of oil from the McClosky lime and refusing to flow. An offset, Sterchi No. 1, is being drilled to the north.

West of Xenie in Clay County, the Carter Oil Company was testing the Aux Vases sand in Keller No. 1, located in 4-2n-5e, which showed for light production.

AVERAGE CRUDE OIL PRICES

California	
Kettleman Hills	$1.23-1.29
Playa Del Rey	.80- .87
Coalinga	.73-1.13
Wilmington	.68-1.24
Montana	1.00-1.15
Wyoming	.47-1.15
Colorado	.95- .97
New Mexico	.70-1.15
Texas	
North Central	.78-1.18
Panhandle	.70-1.12
West Texas	.70-1.12
Gulf Coast	.96-1.51
Darst Creek	1.14
East Texas	.80-1.27
Talco	.79
Kansas	.75-1.25
Oklahoma	.75-1.25
Arkansas	.83-1.30
Louisiana	
Rodessa	.88-1.20
Gulf Coast	.94-1.48
North Louisiana	1.20-1.30
Illinois	1.22-1.37
Kentucky	1.32-1.43
Indiana	1.22
Ohio	
Lima	1.17
Michigan	1.25-1.45
Pennsylvania	
Bradford	2.75
Southwest	2.40
Eureka	2.34
Buckeye	2.30
Corning	1.31

DAILY AVERAGE CRUDE OIL PRODUCTION
Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

	[1]B. of M. Calculated Requirements (October)	Week Ended Nov. 1, 1941	Week Ended Oct. 4, 1941	Week Ended Nov. 2, 1940
Oklahoma	481,500	[2]436,400	432,700	395,300
Kansas	253,000	[2]237,350	239,700	182,700
Nebraska	5,300	[2]6,450	6,450	1,500
Panhandle Texas	.....	80,100	71,500	86,500
North Texas	.....	105,600	100,550	100,600
West Central Texas	.....	31,350	30,450	28,350
West Texas	.....	285,600	231,500	221,150
East Central Texas	.....	85,850	79,700	72,250
East Texas	.....	369,700	298,350	301,400
Southwest Texas	.....	220,000	179,450	208,550
Coastal Texas	.....	291,750	248,800	222,450
TOTAL TEXAS	1,420,100	1,469,950	1,240,300	1,241,250
North Louisiana	.....	80,750	80,350	67,250
Coastal Louisiana	.....	261,400	253,200	214,850
TOTAL LA.	332,000	342,150	333,550	282,100
Arkansas	78,200	72,400	74,350	69,150
Mississippi	43,900	[2]63,300	60,750	16,700
Illinois	399,200	419,800	438,250	353,050
Indiana	20,100	[2]18,000	20,150	20,400
Eastern (not incl. Ill. and Ind.)	98,100	99,450	94,100	92,700
Michigan	44,100	57,950	54,700	47,150
Wyoming	84,300	79,700	88,800	69,650
Montana	20,300	20,000	20,550	18,050
Colorado	5,000	5,750	4,900	3,500
New Mexico	114,600	116,450	114,500	101,450
TOTAL EAST OF CALIF.	3,399,700	3,445,100	3,223,750	2,894,650
California	613,200	626,100	637,000	585,300
TOTAL U. S.	4,012,900	4,071,200	3,860,750	3,479,950

[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of October. As requirements may be supplied from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

[2]Oklahoma, Kansas, Nebraska, Mississippi, and Indiana figures are for week ended 7 a. m. October 29.

Refining

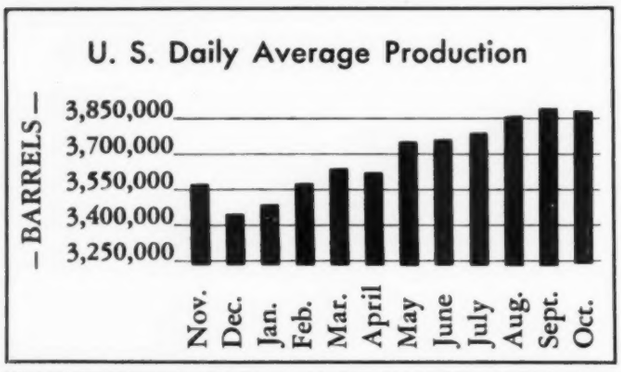
The industry's first still has been preserved for posterity. Constructed in 1854 by Samuel Kier, it had a daily refining capacity of six barrels. This still now reposes in the Pennsylvania State College Museum.

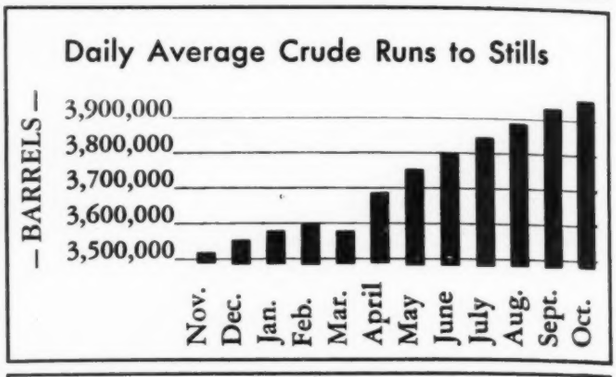
Indicative of its ability to meet the present emergency is the industry's record of growth from this humble origin to the magnitude portrayed by the following summary: Refineries, 557 . . . Daily refining capacity, 4,700,000 barrels . . . Persons employed, over 100,000 . . . Quantity crude processed, 1,294,000,000 barrels per year . . . Lubricating oil produced, 36,765,000 barrels per year . . . Motor fuel produced, 618,000,000 barrels per year . . . Fuel oil produced, 500,000,000 barrels per year.

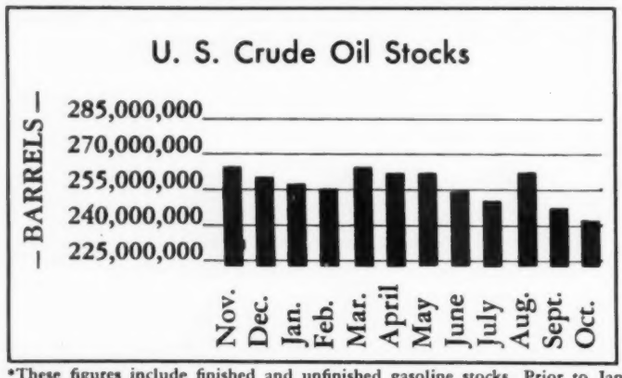
This impressive record typifies the entire petroleum industry. Development of chemical service for oil and gas wells is also due to the progressive attitude of American oil men. As a tribute to them Dowell presents this conception of the first still and reviews a notable achievement.

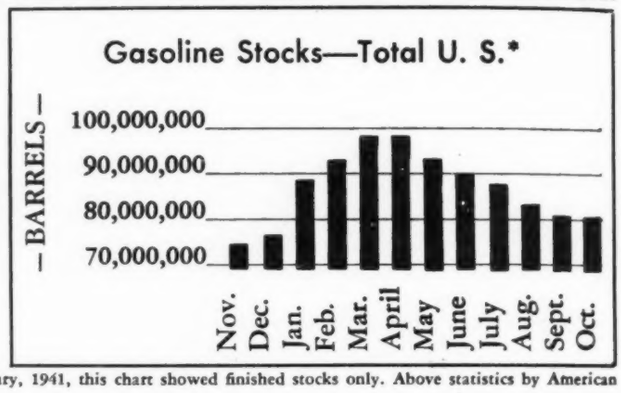
DOWELL INCORPORATED
Executive Office: Midland, Michigan
General Office:
KENNEDY BLDG., TULSA, OKLAHOMA
Subsidiary of The Dow Chemical Company

PETROLEUM *Statistics* AND FIELD *Operations*









*These figures include finished and unfinished gasoline stocks. Prior to January, 1941, this chart showed finished stocks only. Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for October, 1941

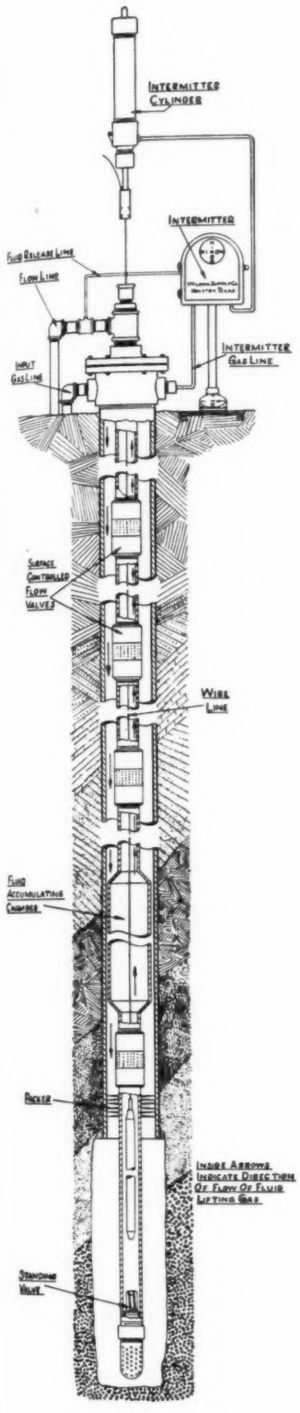
Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	115	96	16	35	3500-3700	2	40	Rotary
Gaines County	13	13	6	15	4400-5584	2	22-35	Rotary
Hockley County	56	56	9	20	4800-6850	2	20-30	Rotary
Ector County	35	34	20	38	3675-4377	2 or 3	32-36	Rotary
Panhandle	76	75	24	88	1700-3900	2	40	Rot.-Cab.
Nueces County	36	31	8	23	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	26	26	7	18	3730-3935	2	42-43	Rot.-Cab.
Hawkins Field	41	41	11	33	4495-4912	2	19-29	Rotary
OKLAHOMA								
Okfuskee County	30	21	12	19	2150-4125	2 or 3	38	Rotary
KANSAS								
Russell County	35	29	8	26	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	22	15	7	16	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	34	25	12	23	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	490	394	390	175	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	21	18	8	20	3150-4030	2	30-34	Rot.-Cab.
CALIFORNIA								
Kern County	44	39	14	30	1840-11.450	3 or 4	14-30	Rotary
Wilmington	21	20	8	9	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for October, 1941

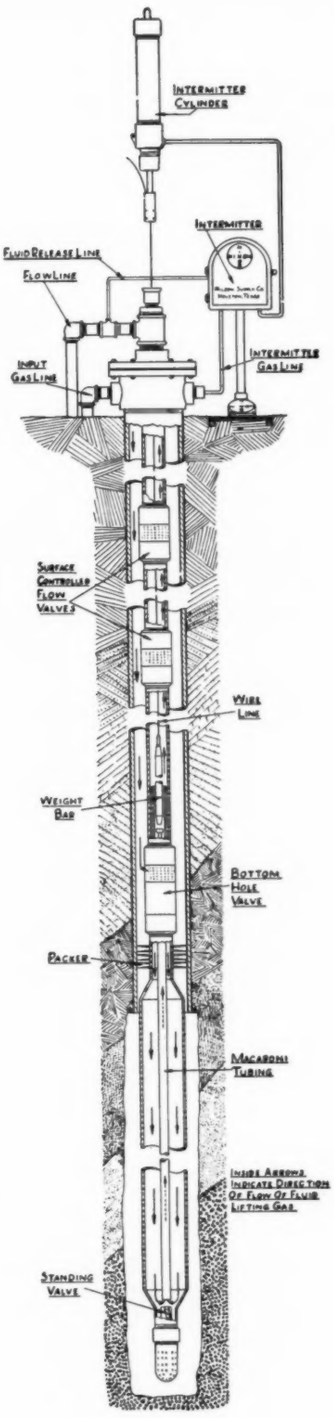
State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1940 (In Barrels)
	October	September	October	September	October	September	October	September	October	September	
Arkansas	38	20	17	14	19	19	10	8	22	15	25,699,000
California	133	123	116	113	66	84	88	89	93	97	224,029,000
Colorado	1	1	....	1	3	....	2	....	1	....	1,369,788
Illinois	490	381	394	321	501	375	390	386	175	162	146,572,938
Indiana	53	38	32	24	70	63	30	26	64	54	4,946,384
Kansas	240	227	173	151	260	197	23	20	160	155	65,602,452
Kentucky	27	42	11	17	45	18	8	12	27	49	5,282,335
Louisiana	192	213	122	154	181	185	60	64	218	227	103,738,728
Michigan	95	100	61	60	135	50	23	27	85	91	19,768,984
Mississippi	44	35	35	30	....	....	....	....	....	....	4,313,159
Montana	38	22	29	18	23	15	8	5	19	16	6,663,872
Nebraska	12	11	10	9	6	4	4	4	8	11	267 533
New Mexico	47	46	41	36	43	36	20	20	41	66	38,893,898
New York	119*	144*	119*	144*	....	....	....	....	....	....	4,240,441
Ohio	200	219	156	170	....	....	....	36	....	....	3,132,280
Oklahoma	224	241	163	177	284	218	64	45	103	114	152,516,049
Pennsylvania	315*	326*	303*	314*	....	....	....	....	....	....	17,987,217
Texas	1103	1198	815	911	1129	1408	793	822	1363	1490	490,101,261
West Virginia	98	87	76	75	47	40	20	20	108	104	3,586,653
Wyoming	12	17	10	14	14	13	7	5	13	21	25,863,538
Total	3481	3491	2683	2753	2826	2725	1550	1589	2500	2672	1,344,576,159

*Includes water-intake and pressure wells.

A NEW MEASURE of ECONOMY for FLUID LIFTING



Closed Intermittent Installation with Fluid Accumulating Chamber



Low Fluid Level Installation

The following patents have been issued on the Nixon Surface Control Gas-Lift System: 2,132,081; 2,136,457; 2,153,770; 2,164,469; 2,171,812; 2,171,478; 2,171,479; 2,171,480; Re 21,199; 2,202,462; 2,204,817; 2,217,072; 2,245,002; 2,245,003; 2,245,004; 2,245,005; 2,245,006; 2,245,007; 2,245,008; 2,245,009, 2,245,010. Other patents pending.

NIXON

Surface Control

GAS-LIFT SYSTEM

(PATENTED)

Hundreds of wells being produced with the Nixon Surface Control Gas-Lift System are contributing more and more factual evidence of the extremely low cost of lifting fluid by this method.

The cost of the original installation is far below that of standard pumping units; operating costs are but a fraction of other methods; maintenance costs are practically nil. All of these economies amount to a substantial saving in the cost of producing your wells.

There is a Nixon Gas-Lift Installation for every type of well and producing condition. Have one of our Engineers show you how to profit by the Nixon Gas-Lift System's "new measure of economy for fluid-lifting." Write your nearest Wilson Supply Company branch store or sales office.

WILSON SUPPLY COMPANY

Branch Stores:

TEXAS: Gladewater, Barbers Hill, Bay City, Monahans, Alice, Victoria, Corpus Christi.
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MAJOR *Pipe Line* ACTIVITIES

NATURAL Gas Pipe Line Company of America has awarded contract to General Contractor W. A. Bechtel Company for 88 miles of 26-in. pipe line in Iowa. H. C. Price Company, Bartlesville, Oklahoma, has contracted for electric welding of the pipe.

General Contractor Ligon and Ligon will lay 45 miles of 12-in. line from Ripley, West Virginia, to Waverly for the Hope Natural Gas Company with H. C. Price Company to electric weld the pipe.

Sheehan Pipe Line Construction Company has contracted for a total of 83 miles of line with welding to be done by H. C. Price Company as follows: Standard Oil Company of Ohio, 10 miles of 12-in. loops in Illinois; Illinois Pipe Line Company, 12 miles of 8-in. near Bridgeport, Illinois, and 6 miles of 6-in. near Wood River, Illinois; Rock Island Pipe Line Company, 2 miles of 8-in. near Zionsville, Indiana; Frontier Fuel Oil Corporation and New York Transit Company, 21 miles of 6-in. and 8-in. near Buffalo, New York, and Mountain Fuel Supply Company, 32 miles of 18-in. from LeRoy, Wyoming, to near Little America, Wyoming.

Panhandle Eastern Pipe Line Company has let a contract for 45 miles of 8-in. line from Galesburg, Illinois, to Peoria to the Oil States Construction Company.

Oklahoma's Cement field in Caddo County now has a large crude oil outlet opened by the Rock Island Oil Company taking 6000 bbl. per day to the new Rock Island Refining Company plant at Indianapolis, Indiana, and the Anderson-Prichard Oil Company taking 8000 bbl. per day to its own refinery at Cyril, Oklahoma. At the Cyril terminal Anderson-Prichard is delivering 2000 bbl. per day to the Magnolia Petroleum Company.

Oil is run from Cyril through the A-P old 4-in. line to the Walters station on the Magnolia trunk line.

The new Rock Island Oil Company line consists of 30 miles of 6-in. pipe extending from the field to the Knox station of the Oklahoma Pipe Line Company, northeast of Marlow in Stephens County. The Oklahoma Pipe Line Company transports the crude oil to Indianapolis.

Construction is expected to begin in the near future on a 16-in. pipe line for natural gas from the Cement field to Oklahoma City, Oklahoma. Pipe is being delivered to the south end of the line. The line is to be constructed by the Cities Service Oil Company and Ray Stephens, Inc., the former having operation of the line, which will tie into the Cities Service trunk system from Oklahoma City to southern Kansas.

Gasoline will be moved through the pipe line to be completed in late November by Williams Brothers Corporation of Tulsa, Oklahoma, before January 1, 1942, for the Southeastern Pipe Line Company from Atlanta, Georgia, to Chattanooga, Tennessee. The line, which originates in Port St. Joe, Florida, was begun several years ago by the Pure Oil Company and Gulf Oil Corporation, but was halted by Georgia refusing to allow the firms to lay their pipe under railway tracks or highways. A special act of congress was required to clarify the matter before the Georgia high courts ruled that the line could be laid under 17 railroads in the state.

The Supply Priorities and Allocations Board has proposed to the office of Petroleum Coördinator Ickes that it might be advisable to build shorter pipe lines than the 1589-mile, 24-in. crude oil pipe line that the SPAB has rejected. The rejection of the line by SPAB is the second handed down by the Board. They formerly refused priorities on welded steel pipe and the second rejection refused seamless steel pipe priorities.

In handing down the second rejection of the line, the board stated that less expensive lines covering shorter distances, might serve to link sources of supply with markets and augment the eastern oil supply at a comparatively minor expense in materials.

SPAB has emphasized its action was not to be construed as rejection of the idea of all pipe-line construction. Ickes has been urged to study all possible methods of assuring oil supplies to the eastern seaboard. Since England has released a number of tankers employed in transporting oil to that country from the United States, the immediate danger of an oil shortage on the eastern coast has been eliminated.

It has been indicated that there are no plans in the petroleum coördinator's office for a shorter oil pipe line under active consideration.

Rogers Lacy, Longview, Texas, refiner, is credited with planning a pipe line into the Hawkins field to supply his plant at Kilgore, Texas, in connection with a gathering system to be built at Hawkins in Wood County. Lacy has obtained in a trade with the Delta Drilling Company, Tyler, Texas, a gas line from Kilgore to Gladewater that will be extended west from Gladewater to the field. In the trade, Delta obtained a gas line system owned by Lacy in the northern part of the East Texas field and will use the system to distribute gas on completion of its carrier from the Chapel Hill field.

Approval of a new financing program totaling $25,000,000 has been given by directors of the Panhandle Eastern Pipe Line Company to acquire certain properties, redeeming the outstanding 6 percent preferred stock, and defraying the cost of construction already authorized. Consisting of $10,000,000 first mortgage with 3 percent bonds, the new financing will have $15,000,000 new preferred stock. If approved, the proposed issues would be offered at competitive bidding.

The company proposes to purchase the Michigan Gas Transmission Corporation and Indiana Gas Distribution Corporation from Columbia Gas and Electric Corporation and certain gas pipe lines in Indiana and Ohio from Ohio Fuel Gas Company for an aggregate consideration of not more than $11,281,326.

It is reported that the redemption of the preferred stock would require about $10,000,000 and the balance of the proceeds, together with funds on hand, to be used to pay for the construction program, which includes the addition of 245 miles of pipe line, looping its present main line system, and the installation of several compressor units.

President of the company, J. D. Creveling, said acquisition of the Michigan Gas Transmission Corporation would result in a unified system as these properties were in effect an integral part of the Panhandle Eastern Pipe Line system transporting natural gas from Texas to Indiana, Ohio, and Michigan.

Stanolind Pipe Line Company will construct an extension of 24 miles to connect the Albert-Otis area of western Rush County, Kansas, and the Pawnee Rock pool of Pawnee County, Kansas, with its present gathering system in Stafford County, Kansas. It is reported that the new line will takeoff from the present system in the northeastern part of township 22-13w and proceed in a westerly direction to the Pawnee Rock pool and then north to the Albert-Otis area. A crew of 150 is scheduled to headquarter in Larned, Pawnee County. Approximately 40 to 60 days will be required to lay the 6- and 8-in. pipe line.

THE Petroleum Engineer

NOVEMBER, 1941

Determination of Slot Sizes for Liners in Argentine Oil Fields

☆ In selecting liner slot size, water encroachment must be considered because of its action in softening the sand, destroying cementation

by D. Federico Ramos Ruiz

Engineer, Yacimientos Petroliferos Fiscales, Argentina

WHEN drilling has been completed in a well and all the productive formations penetrated, it is necessary to provide means for preventing the oil, from carrying sand with it as it flows into the well. Otherwise, serious trouble may be encountered even resulting in complete abandonment of the well. This action, which normally occurs with most sandstones, is more evident in formations having sloughing characteristics due to insufficient consolidation of the formation.

Experience in the fields of Argentina has shown the necessity for maintaining the walls of the drilled well intact so as to avoid changes in its productivity during production. This is accomplished ordinarily by inserting pipe in the bottom of the well, with openings of various designs, which permit passage of the oil but impede the permament flowing of the grains of sand carried with the oil. This procedure is in general use and is indispensable when the casing shoe of the well has been cemented above the productive zone. Other systems are employed that obtain the same results, although it may be because the sandstones are sufficiently consolidated to make the setting of perforated pipe unnecessary. In some cases the casing is run and cemented all the way to bottom and then is perforated through the oil zone; in others the lower part of the string is made up of casing previously perforated.

Producing Formations

The first mentioned condition is the fundamental problem of Comodoro Rivadavia. In this field the oil horizons are composed of particles of diverse sizes within the extreme limits established by the process of sedimentation that originated them, this sedimentation depending on both the mass of the different grains and on the velocity of the water currents. The difference in the size of the particles causes a natural selection of the grains that the fluid carries into the well. This selection is produced in an area of considerable extent around the perforated pipe and to a variable distance into the formation. The distance into the sand ought not to be allowed to become too great and the correct choice of perforated pipe will limit it to a few centimeters, in which case the flow of oil or fluids is practically assured during the productive life of the well.

D. FEDERICO RAMOS RUIZ

after being graduated as an industrial engineer from the National University of Buenos Aires in 1925, entered the employ of Y. P. F. in 1927, first as tower boss and later in charge of cracking at the Fiscal Refinery at La Plata—In 1933 he was transferred to the industrial department of the Direccion General as head of the Division of Research—In 1934 he was advanced to the Department of the Gerencia General as assistant engineer—In 1935 he was sent to the United States to study and upon his return in 1936 was assigned to the Division of Exploitation and Research at Comodoro Rivadavia field—In 1940 he was named chief of the production service in this field, being promoted to the position of chief of technological service in 1941.

The screen analysis of cores will indicate the proper size of the orifices to be used in the perforated pipe, it being established that the width of the slot-type orifice should be approximately equal to twice the size of the "grain" as determined directly by the accumulated percentage analysis. It is also necessary to take into consideration the specific characteristics of the oil in the formation. The most advisable procedure, as developed from the research work conducted by specialists in the subject, will be given later in detail.

Early Development

For a long time during the early stages of development of the industry,

A part of Comodoro Rivadavia field, Argentina

oil wells were produced without using any device to protect the walls from continuous disintegration, the faces of the formation remaining uncovered in the well. The innumerable troubles that resulted through the accumulation of sand and the crumbling of the impermeable high and intermediate strata forced the technicians to look for a necessary solution.

Since the first installations of perforated or screened pipe were made in an effort to curb sloughing of the walls of a well, several different types of perforated pipe have been employed for the purpose. Among them the most common has been pipe with circular orifices, which proved their efficiency in sands of good consolidation by giving the walls the restraint necessary to keep them intact. But in formations not well consolidated the effect of circular perforation was practically nil and the technician soon found it necessary to substitute for this system another that was really efficient even in unfavorable conditions.

Thus there appeared various designs that finally led to a type of slot made directly in the pipe itself. In the Comodoro Rivadavia field in the early part of 1936 the liner with holes was replaced by a type of perforated pipe constructed with bronze slotted plugs adjusted to the orifices that were used previously in the pipe. At the end of the same year longitudinally slotted perforated pipe came into use and was acknowledged by many to be technically and economically superior to the first type by reason of its great simplicity and efficiency. In effect, the first type had the objection of restricting the passageway for fluids through the aforementioned slotted plugs. The slots were of straight cut and the total opening that they provided was equal to only one-fourth of that obtained with the slots of the second type. Also the cost of construction was five times higher.

The second type is made with longitudinal slots of trapezoidal section having the wider base of the slot at the inside face of the pipe. The effective width of the slot is thus the narrower side of the trapezoidal section and this design prevents the plugging of the slots by sand grains that pass to the well.

Comparative Results

The results obtained in practice coincide with theoretical conclusions. The experiments carried on by F. G. Tickell in the year 1927 were afterwards completed by C. J. Coberly, this last work consituting what is probably the most complete that has been published. Since 1936 the production service department of Comodoro Rivadavia has been aided by following the recommendations made by the authors. This was due to the fact that the characteristics and behavior of the formations producing petroleum were similar to those in the experiments by the above named investigators. Thus were established a series of norms relative to the completion of wells, design of the perforated pipe, and correct choice and distribution of the slots in the pipe. Although most of these operations are under the direct control of the geological department it is intended to correlate the said norms for general application, valid for all fields, which may be used by the local field organizations.

Granular Conditions

Inasmuch as peculiar conditions exist in each well relative to the accumulation of sand grains, it is necessary to depend on the screen analysis far enough in advance to show the most convenient method of well completion. All the sizes of grains that compose the oil sand, within certain limits, are not separated into different classifications but are distributed and mixed in a complete conglomeration. At first, a certain quantity of the fine particles runs into the well and as production continues the larger size grains pass down and cling together at the openings of the perforated pipe, thus forming a bridge that impedes the passage of the smaller grains until all the sand grains cease to enter the well. When this natural filter has been built-up by the automatic separation of sand grains it forms layers that can be considered concentric. The larger grains are supported directly over the slots and the others are held behind them in order according to their decreasing size, until the space is filled between the pipe and the sandstone formation, has remained intact and without movement, and which consists of the grains in their irregular mixed position.

Executive offices, industrial plants, and workers' houses in Comodoro Rivadavia field

This process will be slow if, immediately upon completing the well, it is placed on normal production, in which case it will promote mechanical difficulties caused by the deposit of fine sand in the bottom of the well, which will interfere with the operation of the pump and will retard the formation of the natural filter by a decrease in the flow of the fluid from the formation. Knowing these circumstances it is necessary to adopt special means to obviate the difficulties and assure the process of selection, which constitutes an important stage of the method for the good completion of the well. These means are chiefly the careful cleaning of the well and the taking of sand samples during the cleaning operations to determine the character of the sand that is to form the filter until the amount that is carried notably decreases and finally disappears entirely. The tests of these samples will supply additional data of exceptional importance relative to the productive capacity of the well, to its potential, and to the future possibilities of the area being drilled.

Determining Slot Size

C. J. Coberly found that uniform grains of sand were retained almost entirely by slots of double the diameter of the grains. If the width of the slot was made equal to three times the diameter of the grains, all the sand passed through the slot. With the width of the slots understood to be between these two limits, a certain amount of sand passes before the forming of the bridge, the amount being greater as the size of the slot approaches the maximum limit. With the objective of establishing whether the angular form of the grains of sand had some influence upon these results, a test was made with steel balls. These behaved in like manner, the sole difference being that the extreme limits of the slot were found to be between 2 and 2½ times the diameter of the steel balls.

It was found at the same time that in sands composed of grains of different sizes, a small percentage of coarse grains modify the action greatly and increase to a considerable extent the width of the slot on which the bridge is formed. Coberly introduces a new concept that may be called the "effective diameter of the grain," which states that the correct width of the slot is determined by multiplying the "grain" diameter by two. Experiments show that the effective diameter of the grain is not represented by the largest grains that are present in the sample, but by the grain that corresponds to a certain point on a curve of accumulated percentage compiled from a screen anlysis. This percentage varies from 5 to 20 percent on the curve and the form that this assumes influences the establishment of the critical point at which the bridge is formed after a few grains may have passed through the slot.

Curves of uniform gradient, or those that show a regular distribution in the individual percentage of the sizes, will have critical points nearer to 5 percent. An irregular curve, on the contrary, will place the critical point nearer to 20 percent; but in all cases the critical point will be found between these two figures.

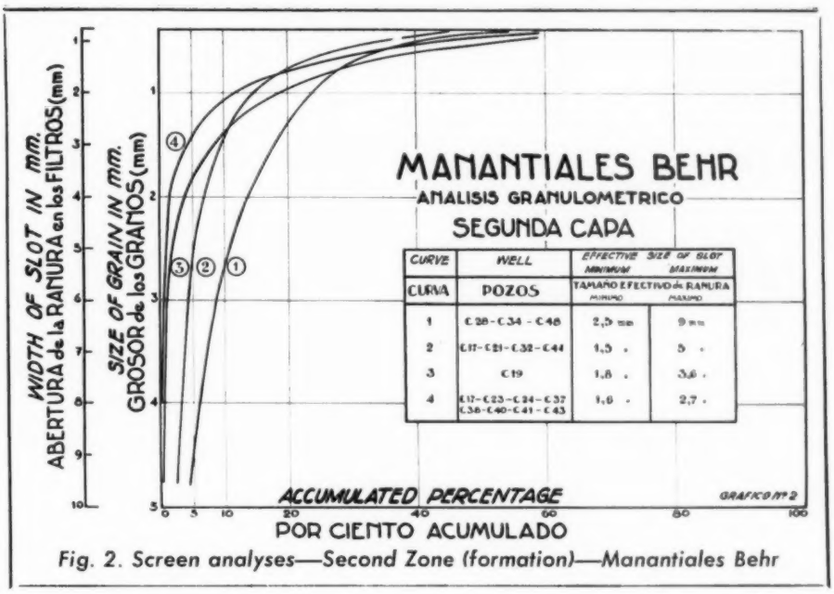

MANANTIALES BEHR
ANALISIS GRANULOMETRICO
SEGUNDA CAPA
CURVE / CURVA
WELL / POZOS
EFFECTIVE SIZE OF SLOT MINIMUM / TAMAÑO EFECTIVO de RANURA MINIMO
MAXIMUM / MAXIMO
1 C 28 - C 34 - C 48 2,5 mm 9 mm
2 C 17 - C 21 - C 32 - C 44 1,5 " 5 "
3 C 19 1,8 " 3,6 "
4 C 17 - C 23 - C 24 - C 37 C 38 - C 40 - C 41 - C 43 1,6 " 2,7 "
WIDTH OF SLOT IN MM. ABERTURA de la RANURA en los FILTROS (mm)
SIZE OF GRAIN IN MM. GROSOR de los GRANOS (mm)
ACCUMULATED PERCENTAGE
POR CIENTO ACUMULADO
GRAFICO Nº 2

Fig. 2. Screen analyses—Second Zone (formation)—Manantiales Behr

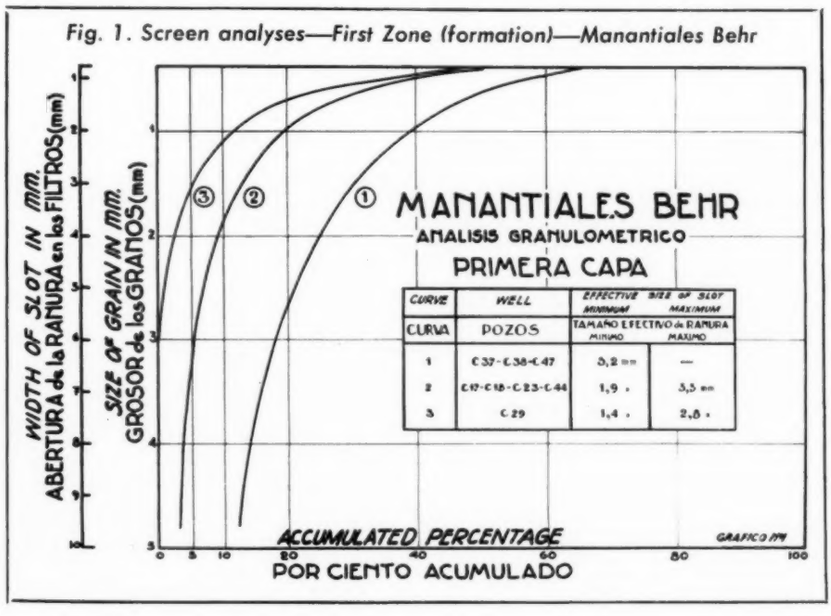
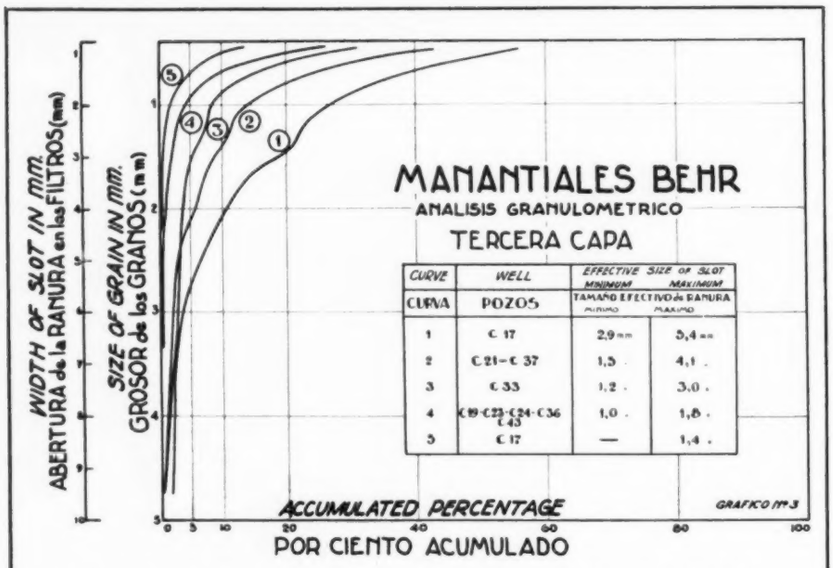

MANANTIALES BEHR
ANALISIS GRANULOMETRICO
PRIMERA CAPA
CURVE / CURVA
WELL / POZOS
EFFECTIVE SIZE OF SLOT MINIMUM / TAMAÑO EFECTIVO de RANURA MINIMO
MAXIMUM / MAXIMO
1 C 37 - C 38 - C 47 3,2 mm —
2 C 17 - C 18 - C 23 - C 44 1,9 " 3,5 mm
3 C 29 1,4 " 2,8 "
WIDTH OF SLOT IN MM. ABERTURA de la RANURA en los FILTROS (mm)
SIZE OF GRAIN IN MM. GROSOR de los GRANOS (mm)
ACCUMULATED PERCENTAGE
POR CIENTO ACUMULADO
GRAFICO Nº 1

Fig. 1. Screen analyses—First Zone (formation)—Manantiales Behr

Granular Cementation

In many wells at Comodoro Rivadavia, however, perforated pipe has been installed where the size of the slots is more than five times the effective diameter of the grain as determined by subsequent screen analysis; in spite of this no difficulties have been experienced from sanding-up. This result should be attributed principally to the tendency that this sand has to segregate into small groups of grains held together by cementation as observed by a screen analysis. This conforms to observations by Coberly, who, in addition to variations in the hardness of the productive sands, also attributes the effect to surface tension of the liquid which, under certain circumstances of flow, permits the formation of a bridge over slots that are wider than indicated by tests.

Such would be the case of the Well C43 of Manantiales Behr. In this well, above the first oil zone and forming a part of it, there exists a porous formation of fine grain whose screen analysis indicates an opening of approximately half a millimeter. Pipe with slots 2½



CURVE / CURVA	WELL / POZOS	EFFECTIVE SIZE OF SLOT MINIMUM / TAMAÑO EFECTIVO de RANURA MINIMO	MAXIMUM / MAXIMO
1	C 17	2,9 mm	5,4 mm
2	C 21–C 37	1,5 .	4,1 .
3	C 33	1,2 .	3,0 .
4	C 19-C 23-C 34-C 36 C 43	1,0 .	1,8 .
5	C 17	—	1,4 .

Fig. 3. Screen analyses—Third Zone (formation)—Manantiales Behr

mm. wide has been placed in the well, however, but future difficulties may arise despite efforts to make it a good producing well. As shown in Figs. 1 to 4, inclusive, larger slots are used in some of the wells producing from the different zones in this pool. In these graphs has been traced the average curve determined by screen analysis of the various productive strata of some wells of Manantiales Behr and the different characteristics of these strata in the same well can be observed. Such conditions, which commonly occur in the sands of Comodoro Rivadavia, make the choice of perforated pipe difficult inasmuch as screen analysis data for the respective zones are not obtained beforehand.

Example

Take the case of the fourth zone of Well C 43 as an example of the procedure that should be followed for the selection of the slot in the perforated pipe. (See Fig. 4).

The screen analysis discloses the following results:

Size of the grains in microns	*Percent*
4760	0.54
4000	0.44
3360	0.18
2830	0.54
2380	0.70
2000	0.50
1680	0.78
1410	2.64
1190	0.34
1000	1.74
840	3.08
710	3.00
590	5.60
500	8.34
less and lost	71.58

Curve (1) is an average constructed from this analysis and establishes the maximum and minimum sizes of the slots as 3.3 and 1.3 mm. for the accumulated percentages from 5 to 20 percent, respectively. The accumulated percentage that would be effective under all conditions is taken to be 10 percent; in which case it would correspond to installing in this zone a pipe with 2 mm.-slots, which would keep back almost all the grains.

The problem would be solved in this way only if applied to a productive stratum. The 2 mm.-slot not only would prevent excess sanding-in but would assure a free flow of oil through the section that the oil reaches. But in other strata of sandstone there exist intercalations of impermeable shale, the grain size of which ought to be taken into consideration both because of their position in the structure and their important characteristic of forming groups of grains that act as individual grains.

Bridging of Sand Grains

If the hard strata are found above the soft or if they alternate, the effect of the grouping of the grains produces, according to Coberly, an effective bridge even when some of the strata may be composed of fine grains, as the space left by these heaving sands that pass through the perforated pipe will be filled by the hard particles coming from the other strata. The example of Well C 43 confirms this by conclusions that have been deduced from the performance of the well. In cases like this, the size of the slot would be greater than that indicated by the 10 percent accumulated as indicated by the analysis.

Inasmuch as the sands of Comodoro Rivadavia do not possess sufficient consolidation it is advantageous to make two screen analyses: a normal one in which the broken-up sand shows its structural composition; and another one taken more carefully so as not to destroy the groupings of the grains that will contribute to the favorable formation of a natural bridge. The necessity for this double analysis will be justified, especially in areas where there exists the possibility of an infiltration of water now or in the future due to the destructive action of the flow on the groupings of the grains.

The situation becomes frankly unfavorable when a soft stratum rests on a firmer stratum as it is not possible then to use a larger slot than the one decided upon from the analysis of the sand removed from the higher formation.

Caleta Cordova Pool

The Caleta Cordova pool would appear to offer extremely favorable conditions as the problem of the bridge would be simplified by the entire productive horizon being formed of only one sandstone stratum. A study of troubles experienced in recent years, however, discloses the reasons for such performance. The screen analyses (Fig. 5) show the sand to consist entirely of fine grains with requirements of slots of approximately 1 mm. wide. The sand is relatively compact and has permitted production of the wells for a long time without great difficulties. This is unquestionable inasmuch as some wells were found equipped with perforated pipe with circular holes and several flowing wells without even liners. It is also evident that the firmness of the sand and the great surface tension of the oil of this zone are the principal causes of such results.

But with the encroachment of water a great deal of trouble has arisen. The new wells that have been equipped with Kobe perforated pipe are less numerous since drilling activity has been limited in that area in recent years; but these wells, producing only oil, have not caused much trouble. The perforated pipe with large size slots that has been installed has proved its efficiency under such conditions. This is not the case, however, with the new wells that showed water from the beginning, and is much less so with old wells making water that were equipped with perforated pipes when being repaired. The water has softened the sand that surrounds the well and has broken down the groups of grains that had formed a natural filter, transforming the sand to an irregular mass of loose grains that pass through the slots. Coberly, in proving this process, established that slots of too great a width when used

in oilfields of this type, will cause disastrous results when the wells begin to produce a considerable amount of water with the oil.

Cutting Slots

A machine that is stationed in the field provides for the making of slots of approximately 1.5 mm. minimum size and is therefore not adaptable to meet the requirements. With blades of lesser thickness, frequent breakage occurs that lessens considerably their efficiency and increases the cost. Notwithstanding, tests are being continued to make slots of 1 mm., although it is not expected that satisfactory results will be obtained in all cases, due to the extreme viscosity of the petroleum, especially in Caleta Cordova, if the unfavorable results obtained with slots of this width or smaller in the area of Restinga Ali are taken as a criterion. It is certain that plugging was produced by the straight cut of the slots but it is possible that the angular cut may eliminate the difficulty to a great extent. Although it requires considerable work, pipe with angular slots of 1 mm. is now being prepared to make a definite test.

The influence of the water on these sands, however, does not permit the harboring of much hope, it being feared that plugging may be produced not only in the slot, but in the granular filter itself. The best solution for this type of formation would be by gun-perforating pipe cemented to the bottom or by gravel-packing. The first process will be tried shortly in a well at Caleta Cordova.

Abrasion Absent

The slot used in Comodoro Rivadavia is made with an approximate inclination of 12°. The necessity for the hardening of the slot, which Coberly recommends to avoid wear on the opening caused by the abrasion of the grains of sand on passing into the well, does not seem to be of fundamental importance in our formation and, up to the present time, it has not been attempted. The perforated pipe of this type that had to be pulled did not present the slightest evidence of abrasion, the slot being kept intact. Furthermore, this phenomenon is the function of the volume of sand that passes through the perforation and the differential pressure of the flow that governs the force of that passage. As the principal function of the perforated pipe is to prevent the passage of the sand and the tests indicate the effectiveness of the bridge for differential pressures as high as 1000 lb. per sq. in., it is obvious that the abrasive action may be reduced as pressures in Comodoro Rivadavia are not generally higher than 200 lb. per sq. in.

Similar tests follow in respect to the resistance of the perforated pipe to collapse or the destruction due to lateral pressures. The longitudinal slots and their distribution and regular spacing over the surface of the pipe conserve the resistance of the cylinder. This is the advantage of the longitudinal slot over the transversal, provided that no appreciable difference exists in what is referred to as the effectiveness of the drainage. The uniform spacing of the slots, in either longitudinal or perimetrical construction, is what gives this type of perforated pipe a greater efficiency when compared with the clustered slots that were used at first and was one of the reasons that motivated their substitution.

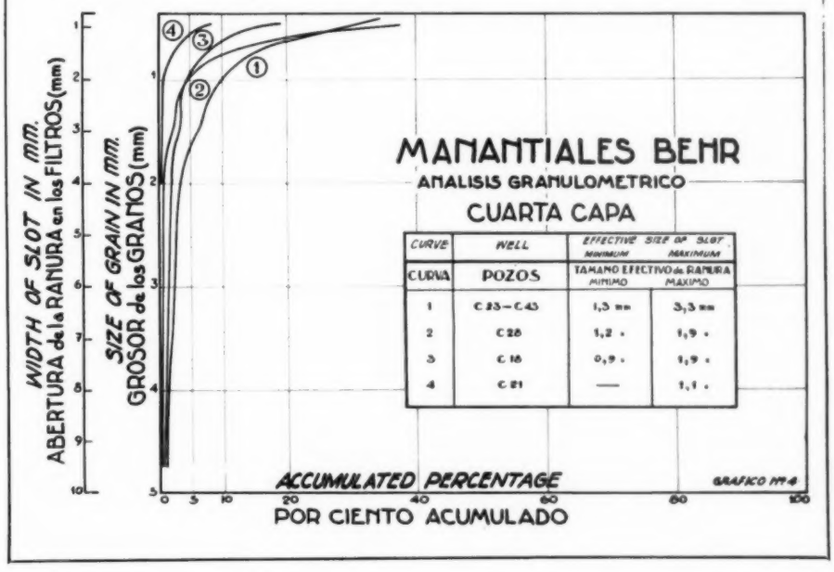
Standard Procedure

As a consequence of the work described in the discussion thus far, it is now possible to establish general standards that indicate the correct procedure to be followed in each case. The Geological Department may proceed at once to take a core in order to make a screen analysis of the sand removed from each stratum and, when the position of the well in the structure might be favorable, may make a second analysis in which it is endeavored to preserve the clusters of grains that are maintained naturally in consolidated units. The compilation of the curves showing the analysis in accumulation percentage can be of great value and will complete the history of the well.

When the productive formation consists of a single zone the filter problem will be limited to the installation of a liner with slots of a size indicated by the screen analysis of the displaced sand, setting it in the cemented casing with a packer or continuing up into the casing with a necessary length of blank pipe for the purpose of preventing sand accumulating behind the liner from passing over the top. If the slot should be smaller than the machine can cut and if the characteristics of the oil permit, the solution would be to cement and then perforate the liner or to use gravel packing. Only in case it is certain that the well will not be apt to produce water would a slot be used of a size indicated by a screen analysis in which there are shown to be groups of grains that are considered as individual grains.

When several zones form a productive horizon and are separated from each other by thin strata of impermeable formation, perforated pipe will be set completely from the top of the first oil zone to the bottom with a uniform type of slot, corresponding to the smallest size that the screen analysis recommends for the different strata. The common size of the slot can be increased only when the strata above might provide disintegrated material that may assure the formation of a filter throughout the length of the entire perforated section. But if the impermeable intercalations have sufficient thickness and consolidation, and if the special condition of each zone should indicate a necessity of using slots of different sizes, it is advisable to place opposite the impermeable strata sections of blank pipe that may assure the process of selection at each of the productive zones. In a similar manner, in case of having deepened the well into a heaving formation that is not productive, it is advisable to make up the

Fig. 4. Screen analyses—Fourth Zone (formation)—Manantiales Behr



CURVE / CURVA	WELL / POZOS	EFFECTIVE SIZE OF SLOT MINIMUM / TAMAÑO EFECTIVO de RANURA MINIMO	EFFECTIVE SIZE OF SLOT MAXIMUM / TAMAÑO EFECTIVO de RANURA MAXIMO
1	C 33–C 43	1,5 mm	3,3 mm
2	C 28	1,2 "	1,9 "
3	C 16	0,9 "	1,9 "
4	C 21	—	1,1 "

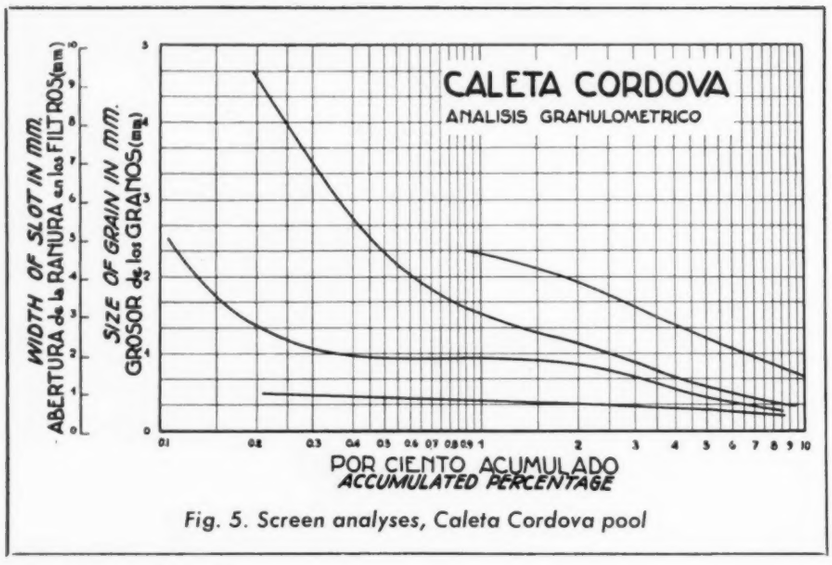


Fig. 5. Screen analyses, Caleta Cordova pool

liner with a blank section of pipe on bottom.

In all cases without exception it would be well to equip the bottom of the liner with a back-pressure valve in the shoe. Furthermore, the procedures that have been outlined will be more effective if the annular space of the well is packed-off by a sealing type of liner hanger so that the sand will not slough into the well and plug up the upper part of the casing until it is impossible to produce the well. All liners should have the commonly used funnel-shaped sub.

When water may be in the bottom of a well or where there is a possibility of encroachment sooner or later, it is possible to avoid a small infiltration by a process similar to the above.

In zones where tests, made of crumbling impermeable formation above the zone or of the strata of shale that separate productive zones, indicate difficulty in the process of selection of the grains of the filter to the point of impeding the production of the well, the procedure most advisable is that of cementing the casing completely to the bottom of the well or cementing blank sections of casing between the producing zones. That part of the pipe lying opposite the oil sands will be gun-perforated in the first case and made with slots in the latter case.

Application Limits

The procedures that have been pointed out as being preferable are only applicable to sandstones that contain grains of different sizes, well differentiated by the screen analysis. But cases exist in which the sandstone is composed of fine grains of great uniformity in which the process of selection cannot be obtained, or it would require a size of slot so small that it would not permit the flow of oil into the well. Experience has demonstrated that wells with these characteristics are very difficult or practically impossible to complete by means of slotted liner. The technician has found, however, solutions to this problem and has proposed two procedures that in practice have been equally efficacious. One is the cementing of the casing or liner completely through the producing horizon and gun perforating; the other is the provision of an artificial filter made of gravel. The first procedure is easily done and does not affect the casing program that may have been established for a specific field. The second, however, requires ordinarily some modifications in the casing program in the completion of the well. The hole diameters have to be larger than in the first case and it is necesary to enlarge the hole at the bottom of the well so as to be able to introduce the gravel between the walls and the liner.

For reasons already given the wells of Caleta Cordova or of areas with similar characteristics would remain perfectly conditioned with the filter of gravel, which would provide advantages that are evident if the previous discussion is taken into consideration. The gravel-pack would assure the cleaning of the well during production and would require less repair for this cause; it would procure a comparatively large initial production and a more uniform later production; and it would eliminate to a great degree the pumping difficulties caused by gas entering with the oil.

Conclusion

The establishment of standard procedures would remedy to a considerable extent the difficulties that are frequently encountered. Nevertheless, it would be appropriate to complete this article with some useful indications relative to the completion of wells as evidence of the efficacy of establishing the method. The major part of these recommendations has already been proposed and included in the standards of well completions that the "Direccion General" is considering.

Without taking into account the wells that flow naturally for which it is not necessary to introduce modifications of the present methods, we will consider the problem of the completion of the wells (exclusively from the viewpoint of their best production in the future) from the moment at which the perforated liner has been installed, or pipe has been cemented to seal completely the oil zones or gravel-packing has been completed. In all these cases the well is still full of mud fluid.

Because of the harmful effect of the mud on the face of the productive formation, it is necessary so far as possible to limit the time of contact and to substitute water for the mud during the time that the slotted perforated pipe is run-in. Until the moment at which the perforated pipe is installed in the well, nothing must be removed nor any agitation set up that may cause crumbling or flowing in of sand; that is to say, everything will be done to maintain intact the walls of the well until the liner is in place.

Before proceeding with tests to determine the productivity of the oil zones and after having substituted water for the mud, the face of the formation will be washed with water by means of Guiberson swab rubbers that force the liquid from the interior of the well through the slots and behind the perforated pipe. If this fails, hydrostatic cleaners that provide suction on the face of the formation are used. Though the choice of slots is based on the grouping of the grains in the screen analysis, it is permissible to substitute water for oil for the washing, or in case of its failure, to carry out the washing with oil after having extracted the water from the well. After a thorough cleaning, established standard methods of putting the well on production are followed.

With the casing cemented and perforated or with slotted pipe between cemented sections, the process to be followed will be the same except that hydrostatic cleaners will be used in place of the washing device because of the difficulty of forcing circulation behind the casing. A like procedure is recommended for gravel-packed wells so as to avoid the clogging of the gravel between the liner and the wall. It is only possible to use the washer if the gravel is in a prepacked liner in which case this method is preferred to the former.

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The driller makes a notation on the drilling time recorder, which is placed at a convenient position at the well

PETROLEUM ENGINEER Exclusive Feature

New Drilling Time Recorder Provides Effective Well Log

☆ Resultant log presents graphic picture of drilling time — Correlates with other logging methods

by Wallace A. Sawdon
Pacific Coast and Foreign Editor

THE acquisition of data, while drilling, that are of value during and/or following the drilling operations is becoming increasingly important in modern drilling technique. Among the records of this character is the drilling time log. The recording of the drilling time may be semi-automatic, fully automatic, or entirely manual; but the result in any case will be a log that will give valuable information. It will indicate formation changes so that possible producing zones may be cored before they are passed up; it will show the exact depth of formation changes and aid the geologist in assigning correct depths to rotary samples; it will supply a graphic record of bit performance and afford the operator the opportunity of increasing drilling efficiencies by proper choice of bits.

A type of semi-automatic drilling time recorder that supplies a record in graphical form and provides correlation of the depth with drilling time, electrical or sample logs without redrafting, computation, or allowance for time spent in other operations is illustrated by the accompanying photographs. The instrument is mounted at the rig within easy reach of the driller and the record obtained (Fig. 1) is shown in correlation with an electrolog curve, both records, of course, being taken in the same well.

Design

The instrument consists essentially of a visual depth chart across which a pen or stylus moves at a constant speed until reset to its zero position by pressing a trigger. Each time the trigger is pressed the stylus carrier is lifted from the constant-speed drive and is instantly returned to the left margin by a spring. Pressing the trigger also advances the chart a fixed distance, so that the time lines of various length are evenly spaced.

The chart itself is 6 in. wide and feeds upward through the recorder from a roll in the lower part of the instrument. Perforations in the edges of the paper provide a means of moving the chart vertically, leaving 5 in. of width for the drilling time record. The drilling time curve is recorded in a 3-in. strip on the left, which is ruled vertically with six timing lines, each line representing five minutes of stylus travel. The full scale represents 30 minutes of stylus travel. The 2-in. column to the right of the drilling time record is available for writing in depths, dates, and any notes that might be desired on the record.

The stylus is carried across the chart at constant speed by a chain driven by a clock mechanism. The clock has a conventional escapement movement but winding is automatic; upon pressing the trigger, which causes the stylus to return to the left margin, all energy taken to make the stylus travel to the right is put back into the clock spring. When the stylus travels the full distance across the chart the clock automatically stops.

For direct correlation with electrical logs, the chart is designed to move 2 in. for each 100 ft. of hole drilled, or one-fiftieth (1/50) in. per ft. The usual constant depth interval is 1 ft. and the ratchet advances the chart one-fiftieth in. each time the trigger is pressed.

Pressing the trigger of a drilling time recorder

recorder until drilling begins again. Likewise, when extremely dense streaks are encountered, requiring more than 30 minutes per ft. to drill, the recorder may be shut off. The driller should note the number of inches drilled in 30 min. as a matter of record. In this way a continuous depth chart of drilling time is made, which is an actual finished log of the hole, drawn to a true depth scale and directly comparable with other types of well logs without redrafting or revision.

If the driller has instructions to core all soft formations in a certain depth range, the visual record before him shows graphically the entry of the bit into softer formations. The drilling time lines change in length from say, 3-in. (30 minutes) per 1-ft. interval, which is the maximum, to a very small fraction of an inch, when the bit drills out of a hard shale into a soft sand.

——☆☆☆——

Speed Variation

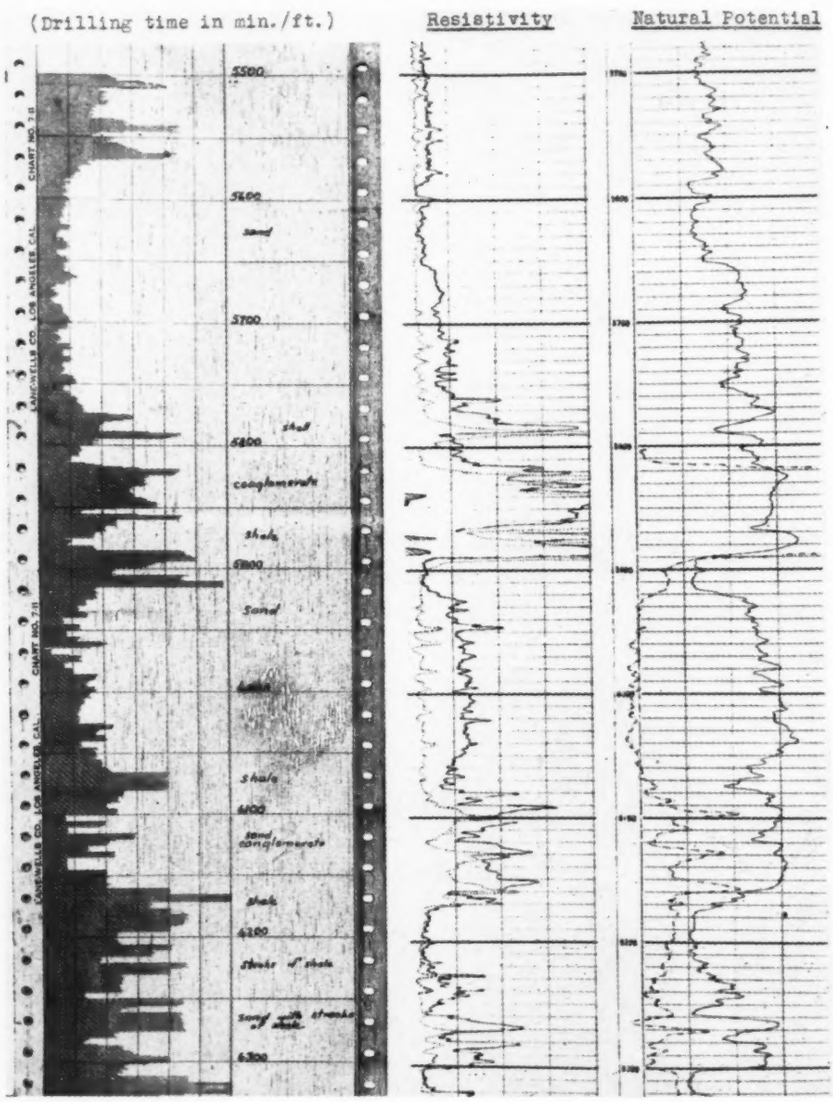
Inasmuch as the hardness of formations vary greatly in some wells a device has been incorporated that allows for the drilling of 2 ft. or 5 ft. instead of the usual 1 ft. between movements of the chart. In order to keep the vertical scale constant under all conditions the chart is moved one twenty-fifth (1/25) in. upon pressing the trigger when the setting is for 2 ft. and one-tenth (1/10) in. when the setting is for 5 ft. Due correction will, of course, have to be made to convert the drilling time into minutes per foot when either the 2-ft. or 5-ft. interval is used.

Operation

When the interval for timing is 1 ft., the driller has the kelly marked or "striped" at 1-ft. intervals. The chart is then set so that the depth of the hole is correctly indicated on the depth scale of the chart and the recorder is set in motion simultaneously with the beginning of drilling. The stylus begins making a drilling time line at the proper depth on the chart and runs continuously across the chart at the rate of 1 in. each 10 minutes. When the first 1-ft. mark on the kelly comes down to the rotary table, indicating that the first 1-ft. interval has been drilled, the driller presses the trigger. This resets the stylus at zero time and moves the chart the equivalent of 1 ft. in depth. The stylus now starts across the chart again drawing a line the length of which will be a measure of the time taken to drill the second 1-ft. interval.

Whenever actual drilling is stopped for any reason, the driller shuts off the

Fig. 1. Comparison of drilling time log with electrical log



General view of Lion's purification plant

The compressors discharge at pressure of 540 lb.

Gas Purification Plant in Magnolia Field, Arkansas

☆ New installation provides for removal of hydrogen sulphide and carbon dioxide from 15,000,000 cu. ft. of natural gas daily

by Frank H. Love

Managing Editor

IN the Magnolia field, Columbia County, Arkansas, the Lion Oil Refining Company has recently completed a plant for removal of hydrogen sulphide and carbon dioxide from natural gas. The gas being treated is residue gas from the gasoline plant of the Shell Oil Company, Inc., in the Magnolia field, and from the Village field, about 6 miles distant. The latter gas is obtained direct from field separators. The principal volume at present is from the Magnolia field. Gas from both areas is somewhat high in hydrogen sulphide content. Magnolia field gas contains 1350 grains per 100 cu. ft. and Village field gas 220 grains. This, together with carbon dioxide, is being removed by the Girbotol process, the plant having a rated capacity of 15,000,000 cu. ft. per day. The present throughput is 14,000,000 cu. ft.

Residue gas from the Shell gasoline plant is metered in that company's yard before being discharged to the purification plant, which is immediately adjoining. The separator gas from the Village field is metered upon arrival at the treating plant and the two gas streams join in a common line ahead of the absorber. The residue gas is received at a pressure of approximately 150 lb. per sq. in. Gas from the Village field is received at a pressure of 225 lb., which is reduced to 150 lb. by a reducing valve before joining the Magnolia field gas in an 8-in. line to the absorber.

The gas stream enters the 5-ft. diameter by 51-ft. high absorber at the bottom of the tower and passes upward through Raschig rings, where it is contacted by the absorbing medium, a water solution of diethanolamine. As the sour gas rises upward in the absorber it flows countercurrently to the absorbing solution, which is pumped continuously into the tower near the top. The gas enters the absorber at a temperature of approximately 100°F. and is discharged at a temperature of 95°F. In the tower the hydrogen sulphide content of the gas is reduced from 1500 grains per 100 cu. ft. to less than 5 grains. Carbon dioxide is also removed from the natural gas in the absorber column. The natural gas with hydrogen sulphide and carbon dioxide removed is discharged to the suction of three 8-cylinder, 300-hp., V-type compressors, being taken at a pressure of 150 lb. per sq. in., and compressed by single-stage compression to a discharge pressure of 540 lb. per sq. in. The temperature of the gas during compression is increased from 90°F. to 235°F. After it leaves the compressors the gas passes through a 6-in. line to a 5-bay cooling tower where the temperature is reduced to 90-95°F. The gas is then cleaned in a 4-ft. diameter by 10-ft. high scrubber prior to being metered into a line that transports it to El Dorado and Smackover. The desulphurized gas is used for fuel in the Lion Oil Refining Company's refinery at the former point and as fuel for lease operations at Smackover.

The solution of diethanolamine saturated with hydrogen sulphide and carbon dioxide flows by absorber pressure from the base of the absorber, through a heat exchanger, to enter a 6-ft. diameter by 52-ft. high bubble tray reactivator. Entering at a temperature of 230°F., the solution flows downward through the reactivator, passing over bubble trays. From the bottom tray the solution flows to the reboiler where it is heated to its boiling point, ap-

proximately 260°F., at the reactivator pressure of 15 lb. per sq. in. gauge. The liberated hydrogen sulphide, carbon dioxide, and steam are returned to the reactivator through a 10-in. line, and leave the reactivator at the top of the tower at a temperature of 235°F., passing through the acid gas cooler where the steam is condensed and is discharged to a reflux drum from where it is pumped back to the reactivating tower. The hydrogen sulphide and carbon dioxide are discharged to a flare and burned.

The completely reactivated absorption solution leaves the reboiler and enters the bottom of the reactivating tower, which acts as the lean solution reservoir. This lean solution flows by reactivator pressure through the heat exchangers and is pumped by centrifugal pumps through the solution coolers to the absorber tower, the cycle of the absorption solution, diethanolamine and water, being continuous.

Steam Supply

Steam is generated by three 110-hp. boilers operating at 300 lb. per sq. in. pressure. Steam from the boilers flows to the water and solution pumps, and exhaust steam from these pumps goes to the reboiler. The reboiler is given additional live steam as needed, a recording flow controller regulating the discharge of steam directly from the boilers to the reboiler. Condensate steam passes from the reboiler to a hot water tank to be used as boiler feedwater. Approximately 12,000 lb. of steam is used per hour by the plant when on full load.

Water

Water is used for cooling the solution of diethanolamine before it enters the absorber, for cooling the acid gases (hydrogen sulphide and carbon dioxide), as make-up for boiler feed, and as engine jacket cooling water. From a 400-ft. well, water is pumped by a deep-well type pump into a 300-bbl. water tank. From this tank the water goes to the boiler feedwater tank, and to the basin of the cooling towers. Steam-turbine-driven pumps pick-up the water from the basin of one of the towers and pump it through the diethanolamine solution and acid gas coolers, then to the top of the tower.

Cooling Towers

There are two cooling towers. One is used for cooling engine jacket water and the discharge gas from the compressors. This is a 5-bay tower. To cool the engine jackets the water is circulated continuously in a closed system from the engines to the cooling tower and back to the engines. The other tower, which is for cooling water used in the purification plant, has nine bays.

Electric Power

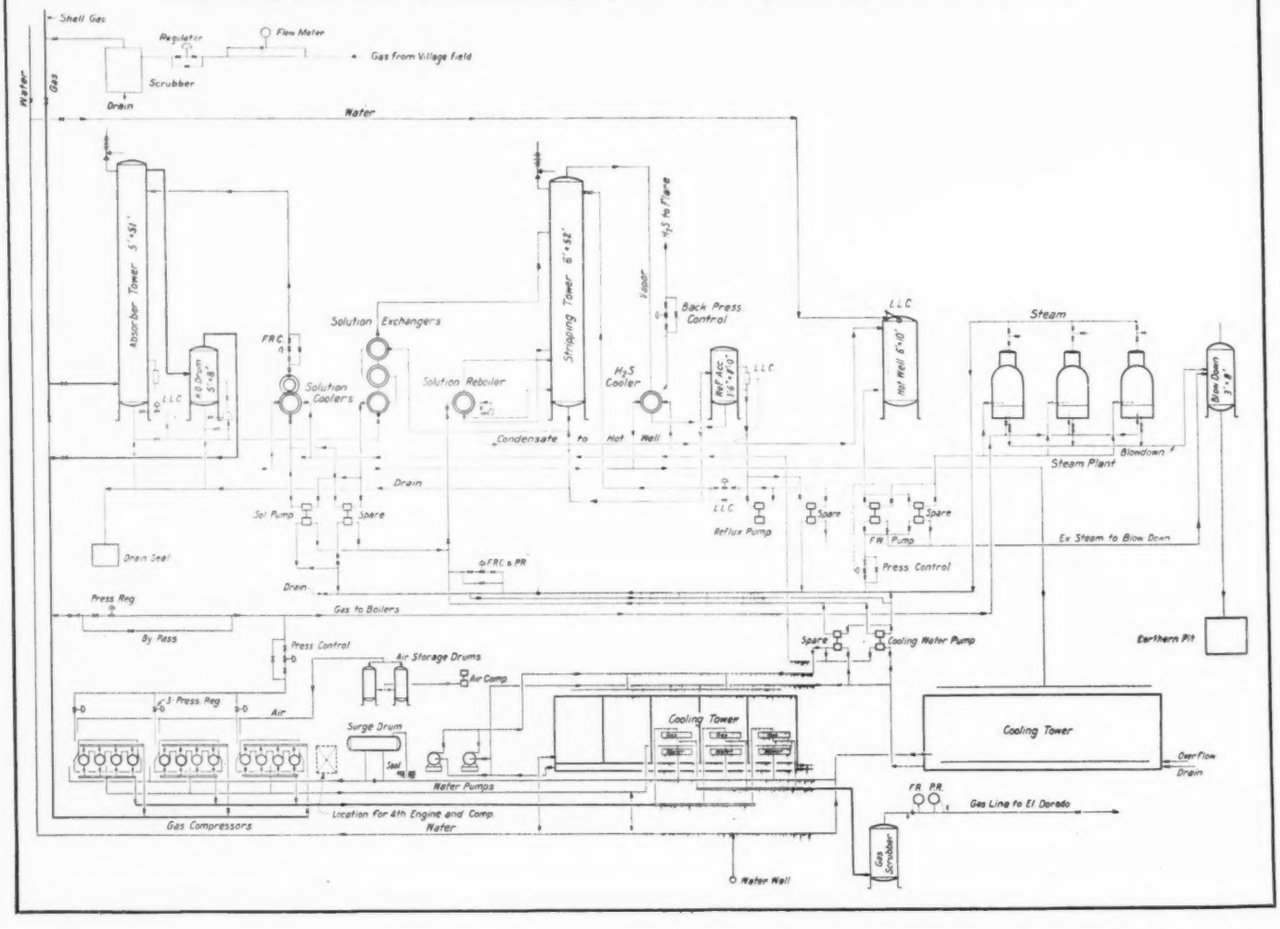
Utility electric power is purchased and used to supply the several motors used in various services throughout the plant. The water-well pump is driven by a 15-hp. motor; two centrifugal pumps (one a standby) for pumping water over one of the cooling towers are driven by 10-hp. motors, and the standby reflux pump also is motor driven. In addition, electricity is required for plant lighting and for the 5-hp. air compressor, the latter providing 225-lb. starting air to the compressor units. For the motors 220-volt power is provided and for lighting purposes 110-volt power.

Miscellaneous

The Girbotol Process, as used in this plant, is patented by the Girdler Corporation, Louisville, Kentucky.

☆☆☆

Flow diagram of Lion Oil Refining Company's purification plant, Magnolia field, Arkansas



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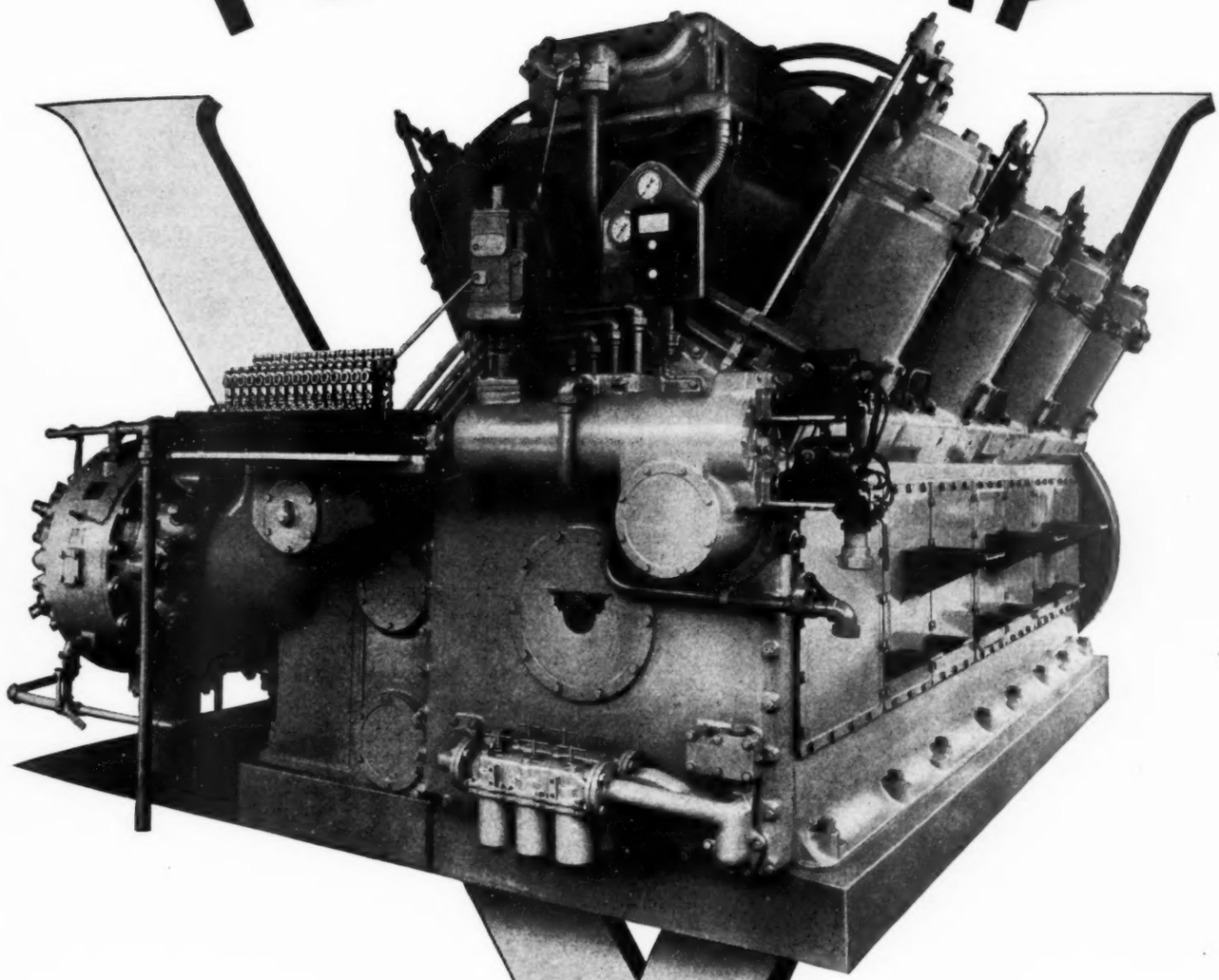

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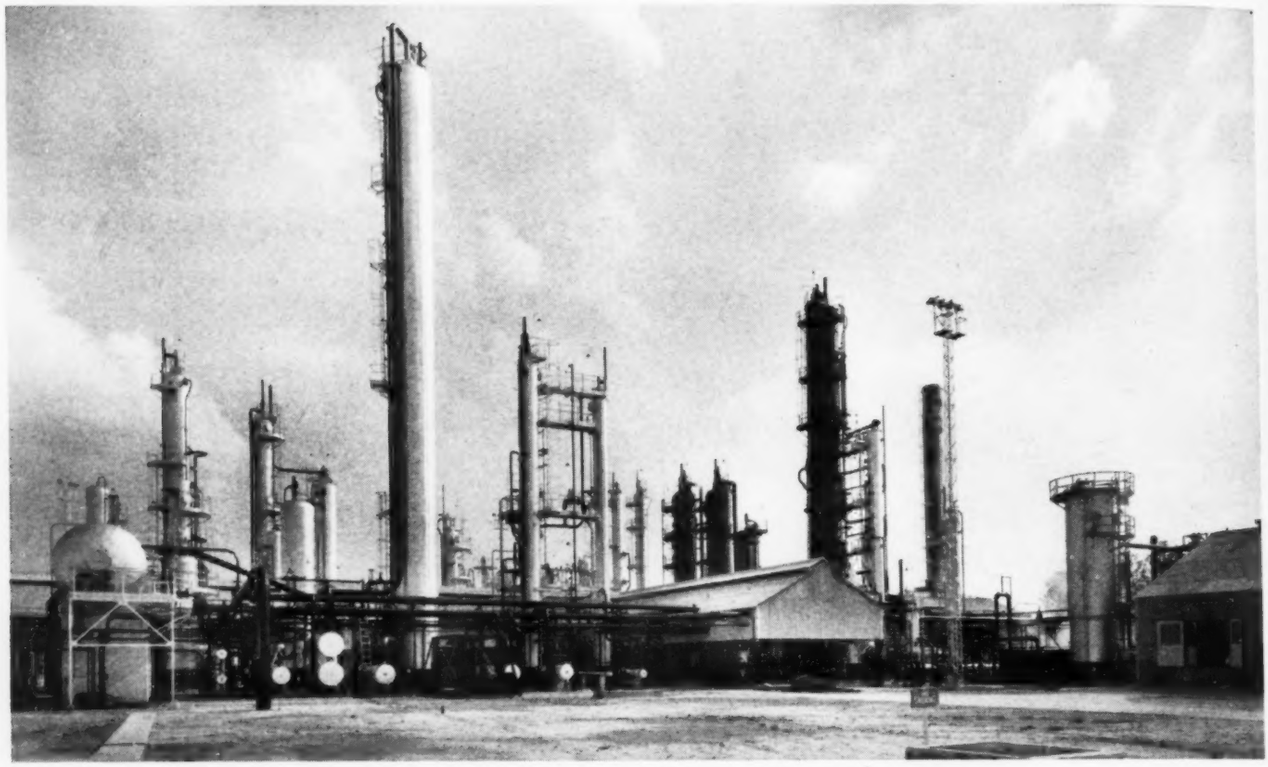


Equipment in the left foreground constitutes the alkylation plant. The tallest tower is the isobutane tower; on the right is shown the water-treating plant and a corner of the electric generating plant

Details of New Refinery Installation on Louisiana's Gulf Coast

PETROLEUM ENGINEER Exclusive Feature

☆ **Alkylation and polymerization units augment skimming and cracking facilities**

by H. Lee Flood

Associate Editor

CONSTITUTING one of the most important single additions to Gulf Coast refining capacity, the refinery recently completed by Continental Oil Company at Lake Charles, Louisiana, embodies many of the more advanced principles of refining technology, integrated and balanced in such a way as to make the plant one of the most efficient ever constructed.

At Lake Charles, every element comprising the plant shows thought and study, backed by practical operating experience. The layout of the facilities in their relationship each with the other, the provision of ample space for driveways between the units, the control room centrally located in the heart of the processing area, the liberal but judicious use of automatic and other types of control equipment, are only a few of the features that have helped reduce the operation of an otherwise complicated group of processes to a matter of relative simplicity.

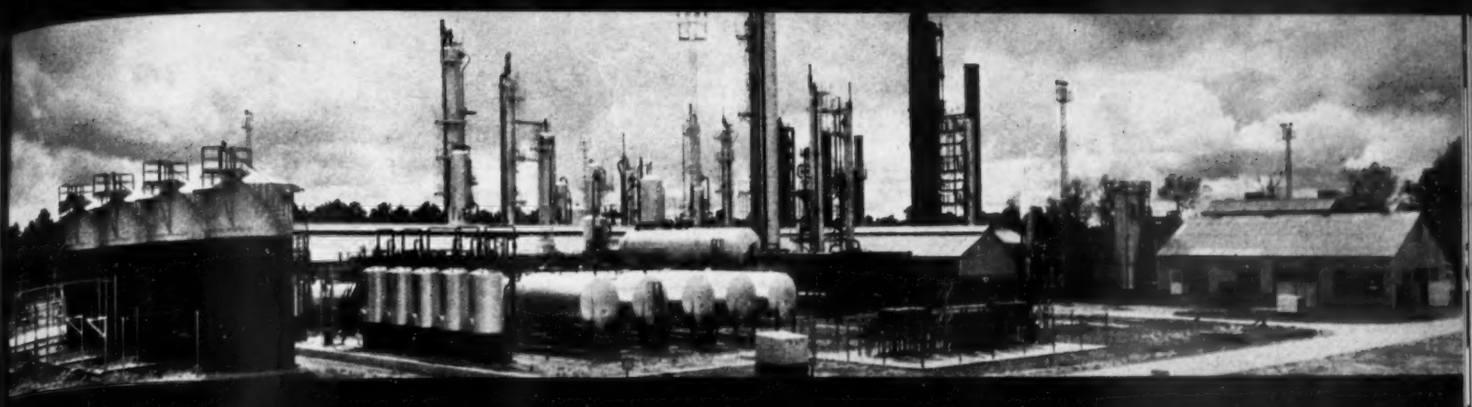
Brief Description of Plant

The Lake Charles refinery is termed a combination topping, cracking, gas reversion, thermal polymerization, and alkylation unit. Thus the plant incorporates improvements of some of the older and better-known processes found in a conventional refinery with two of the more recent processes that utilize as charging stocks refinery and natural gases that formerly were wasted or burned as boiler or furnace fuel.

The relative capacities of the various units have been so accurately balanced that every hydrocarbon is utilized. Gases formerly wasted or burned are reformed and combined to produce motor fuel and the relatively small volume of gas that is not readily condensable is utilized as plant fuel.

The refinery is designed to process a combination charge of 10,000 bbl. of crude oil and 6000 bbl. of 70-lb. PBC (propane-butane-casinghead) stock daily, all of which is piped from the Ville Platte and Tepetate fields, situated farther north in Louisiana.

The refinery site was chosen adjacent to the company's marine terminal at Lake Charles. Prior to erection of the refinery, virtually all crude oil pro-

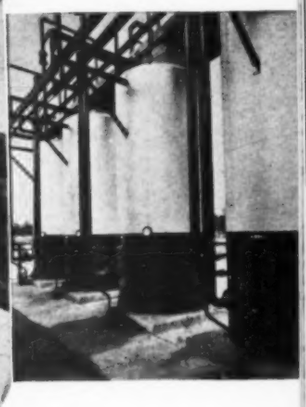


TOP PHOTO: General view of Lake Charles Refinery.

BELOW: Nordco Steel Valves on gasoline storage tank lines.

AT LEFT: Nordstrom Valves on manifold of gasoline lines.

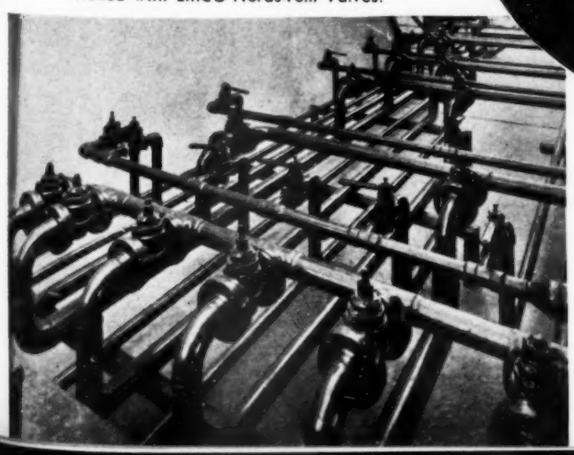
BELOW: Nordstrom Valves on treating tanks.



Continental's new thermal polymerization refinery at Lake Charles, completed at a cost of $4,000,000, gives National Defense another boost with production of 100-octane gasoline. It's the last word in modern equipment. This refinery is equipped with Lubricated Plug Valves for practically every major valve operation throughout the plant, to assure safety, ease of control, assurance against sticking, and protection from corrosion and erosion.

In this magnificently engineered refinery every valve that could be is a lubricated plug valve. Hundreds of Nordstroms are in service here—wrench and gear-operated types, Standard and Hypreseal styles, some with remote control, on high and medium temperature lines, at various working pressures. We congratulate the Engineering Staff of the Continental Oil Company upon the successful completion of this outstanding refinery and their contribution to the national emergency.

BELOW: Finished products manifold controlled with EMCO Nordstrom Valves.



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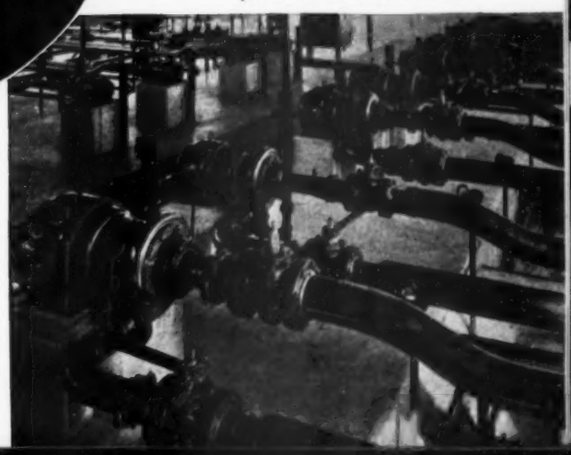

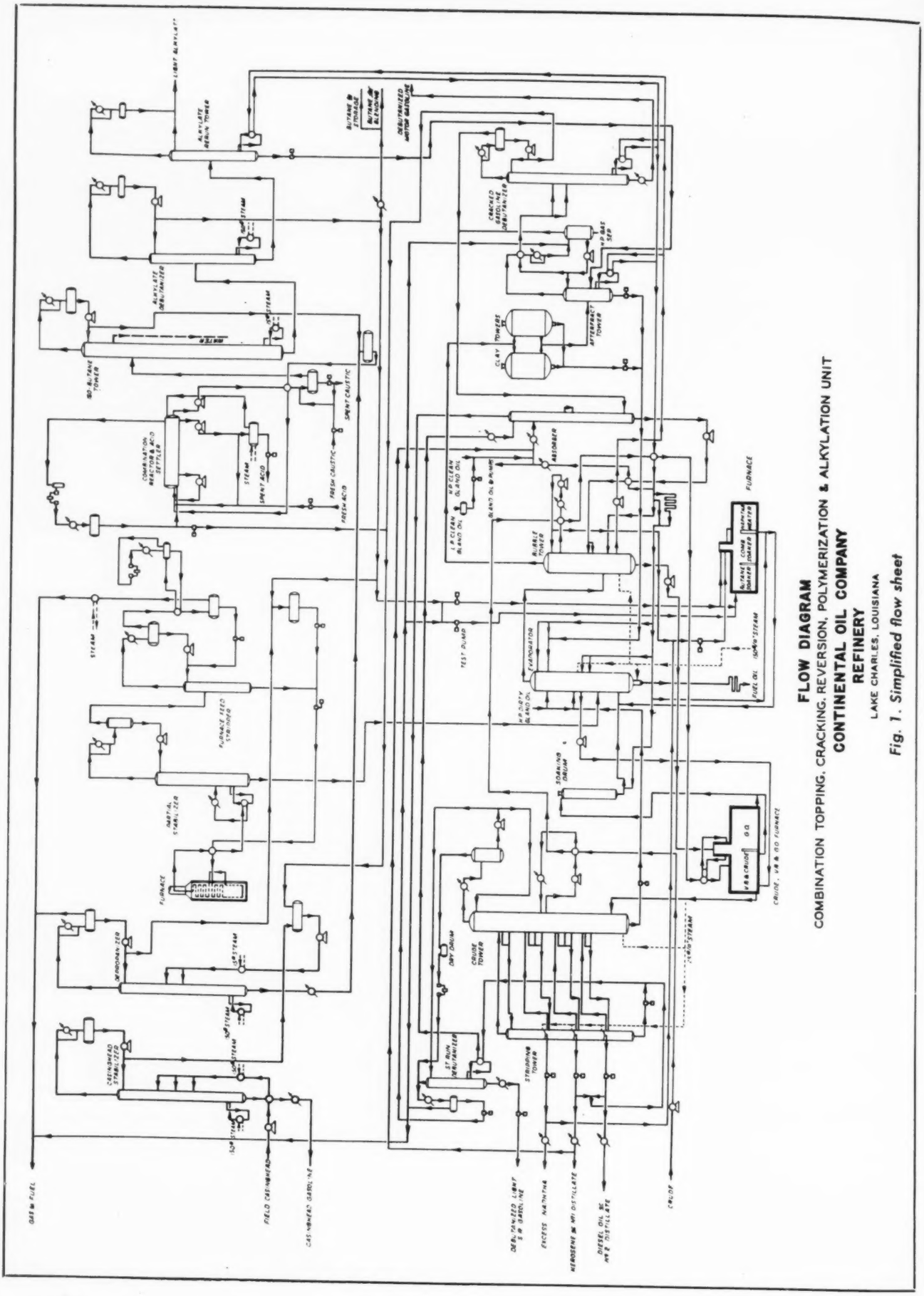

Fig. 1. Simplified flow sheet

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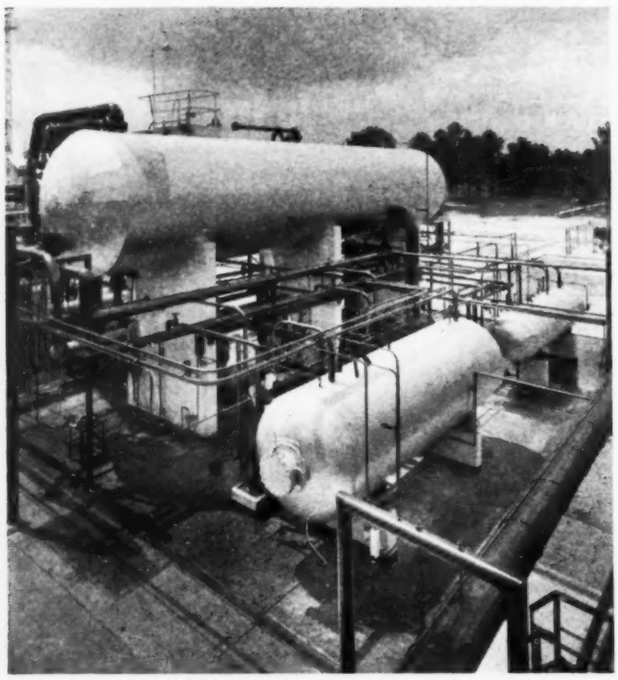
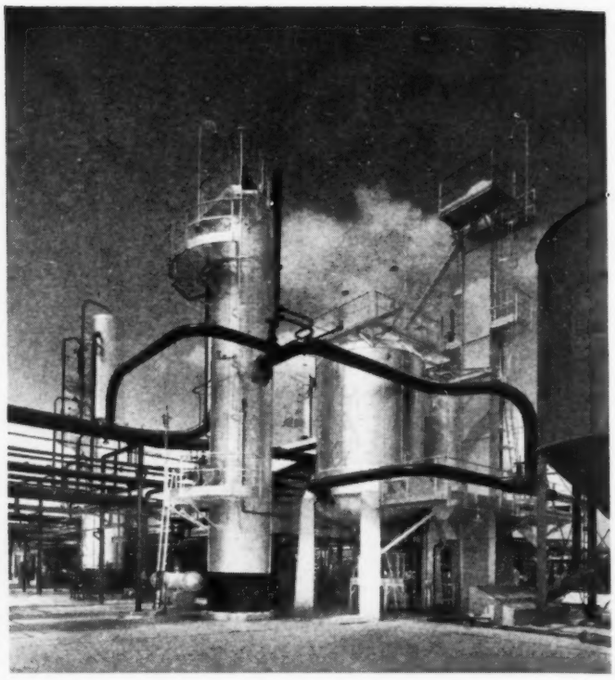


Acid-contact equipment in alkylation plant. Elevated vessel is 3-compartment acid-reactor chamber



Vertical column in center is afterfractionator tower; the two clay towers are adjacent to the afterfractionator and are fed by the tall bucket elevator from the clay storage tank shown on the extreme right

duced or purchased by Continental in Louisiana was delivered to this terminal for shipment by tanker to the company's refinery at Baltimore, Maryland, or for sale.

Crude oil produced in the Ville Platte and Tepetate fields is stabilized in field plants by removing all propane and a portion of the butanes. Prior to the installation of the Lake Charles refinery, there was no economical method whereby these lighter hydrocarbons could be utilized. These lighter fractions are now blended with the casinghead or natural gasoline to a Reid vapor pressure of approximately 70 lb. per sq. in. and are piped to the Lake Charles terminal and then are transferred to the local refinery. The stabilized crude oil has an average A.P.I. gravity of approximately 40°. The analyses of the two crude oil stocks are shown in Table 1.

Description of Flow

Crude oil processing*. The incoming crude oil is pumped by a 3 by 4 by 7½—4-stage centrifugal pump (driven by a 100-hp. non-condensing steam turbine) through a series of heat exchangers as follows: (1) countercurrent with the intermediate reflux in the crude tower; (2) countercurrent with the top reflux in the bubble tower; (3) countercurrent with gas oil being returned to the evaporator, after serving as heating medium for reboilers, and (4) through an auxiliary exchanger in exchange with gas oil prior to entering the crude coil in the 3-coil furnace. The latter exchanger is used only when the charging rate is high and additional heat is required in the charge to the crude coil in the furnace.

From the furnace, the crude oil enters the base of the crude tower (E-1)†. This tower has both top and intermediate reflux facilities. The products from the crude tower are disposed of as follows:

(1): The gasoline taken overhead from the crude tower goes to the straight-run debutanizer tower (E-3), then to storage after treatment with a light doctor wash. The butane removed overhead in E-3 is processed through the alkylation unit for the conversion of its isobutane content to alkylate and then joins the butane removed elsewhere in the plant and goes to the butane reversion furnace as charge stock.

(2): Naphtha is taken as a side cut from the crude tower and is further fractionated in the stripping tower (E-2). When charging rates are high, excess naphtha may be stored as such. Normally all naphtha produced is utilized as charge stock to the naphtha coil in the reversion furnace.

(3) and (4): Kerosine (No. 1 distillate) and Diesel fuel oil (No. 2 distillate) are taken from the crude oil tower to the stripping tower, removed as side cuts, and pumped to storage, ready for market. Provision is made for subjecting these products to a light caustic wash when necessary.

(5): The topped crude from the base of the crude tower is pumped to the viscosity-breaker accumulator in the evaporator tower where it is joined by the heavy recycle. From the accumulator, the viscosity-breaker furnace charge pump (J-11) transfers the charge to the viscosity-breaker coil in the 3-coil furnace. After passing through the furnace the cracked oils join the output from the gas-oil coil and the mixed stream goes to the soak-

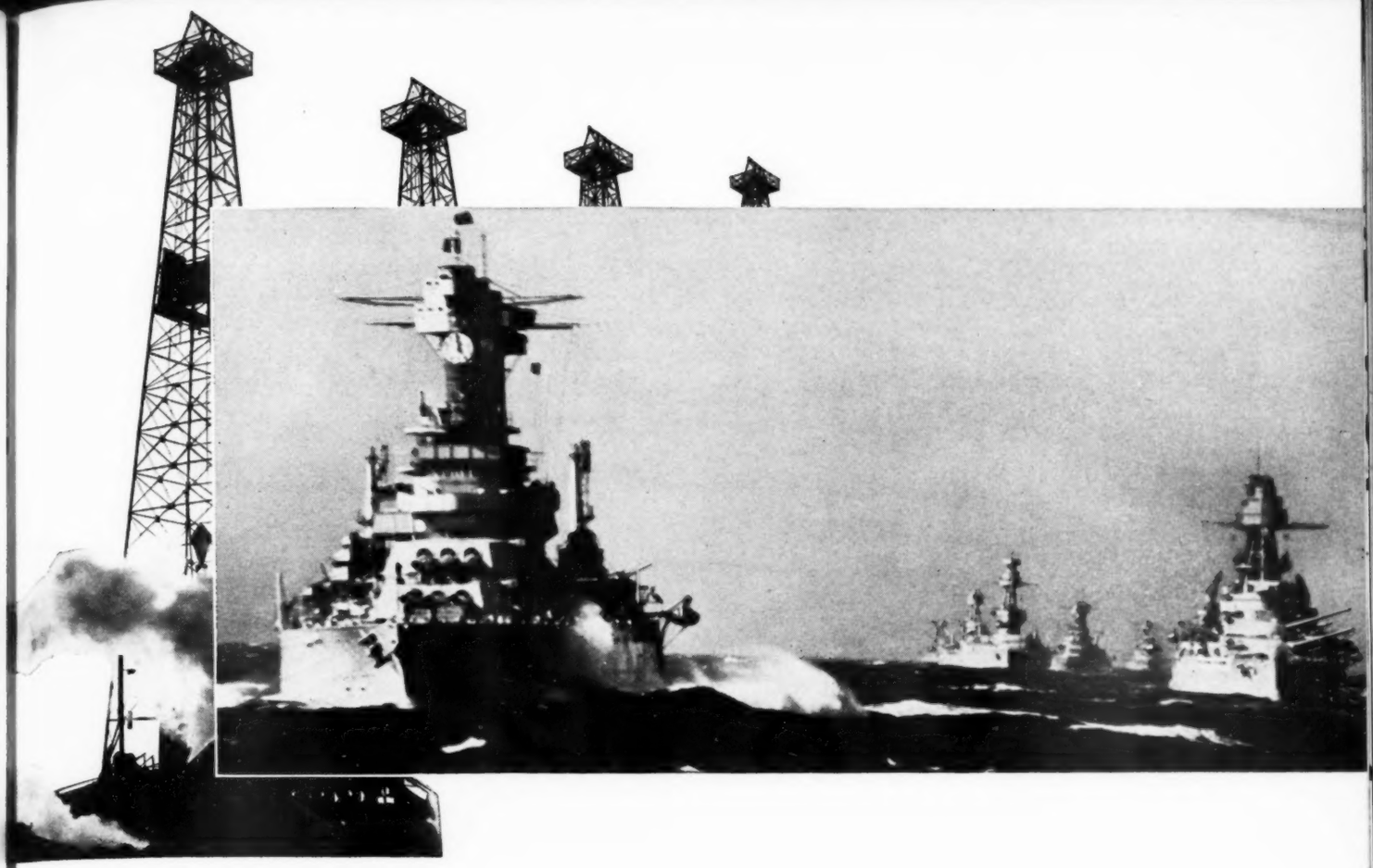
TABLE 1
Crude oil analyses

	Crude oil from:	
	Tepetate field	Ville Platte field
Gravity, A.P.I.	35.6	43.1
Viscosity at 70 F., SSU	51.6	39.8
100 F., SSU	41.6	34.4
Vapor pressure (ASTM)	3.7	7.8
I.B.P.	114	104
5%	186	192
10%	228	254
30%	400	324
40%	500	400
50%	566	490
60%	634	562
65%	652	...
70%	654*	635
80%	...	680
85%	...	690*

*Cracking.

*In tracing the flow through the refinery, the main stream will be followed as closely as possible to avoid confusion. In the modern refinery, however, so much stock is recycled, rerun, or otherwise re-introduced into the processing that it is necessary to retrace the flow occasionally in presenting a complete description of the plant.

†Symbols refer to lists in Tables 2 and 3.



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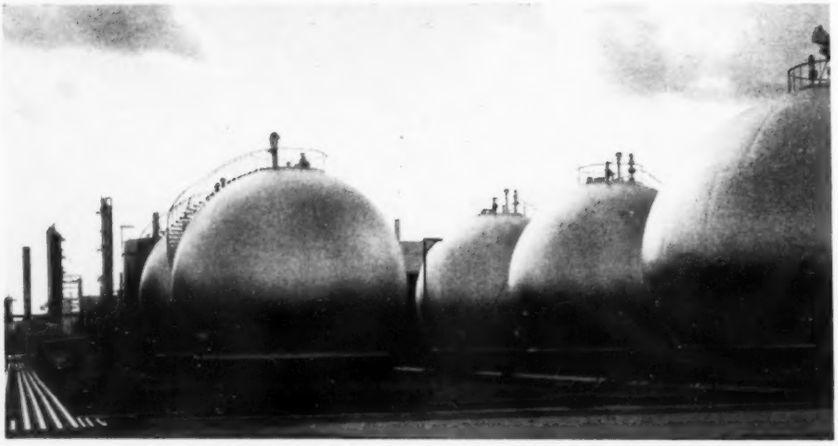


Spheroidal pressure tanks for storage of liquefied gases and casinghead gasoline

ing drum (E-4). In the soaking drum additional time is provided for the cracking reaction.

From the soaking drum the cracked stock goes to the evaporator tower (E-5). (Note: The output from the butane furnace is mixed with the cracked stock just before entering the evaporator.)

The evaporator can be considered as the utility vessel of the plant. To it are returned all stocks that need to be cleaned-up. Among the streams that are received by the evaporator are the following:

(1) The mixture of heavy gas-oil (from the viscosity-breaker coil) and clean gas-oil (from the gas-oil coil).

(2) The output of the reversion equipment.

(3) Polymer gasoline from the partial stabilizer (E-13).

(4) Polymers removed from the cracked gasoline.

(5) Contaminated gland oil from the viscosity-breaker charging pump (J-11).

The principal purposes of the evaporator are to separate a marketable fuel oil, preheat the viscosity-breaker furnace charge, and to clean up the stock used to charge the gas-oil coil in the 3-coil furnace. This latter stock is taken overhead to the bubble tower (E-6) and the bottoms from the evaporator are drawn-off, cooled, and pumped to storage as marketable fuel oil.

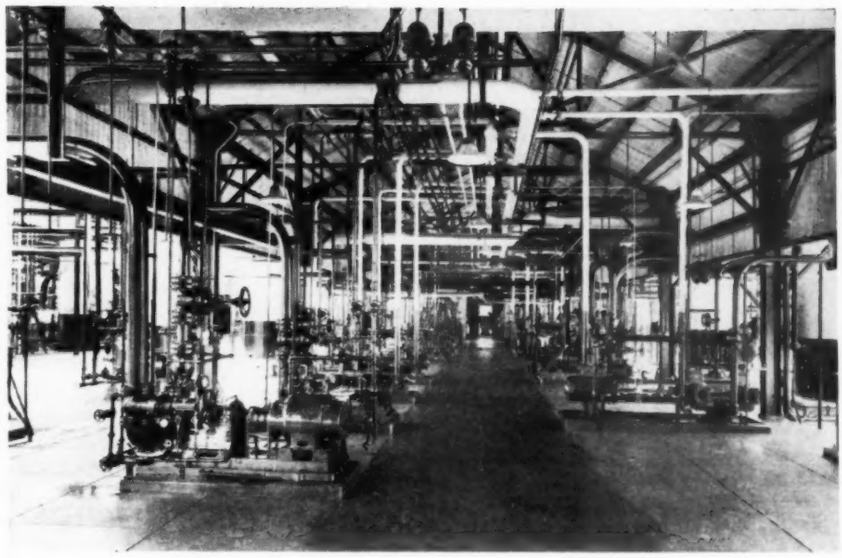
The overhead from the bubble tower is cracked gasoline that then goes to the clay towers (E-7) for the clay-contact treatment. After a preliminary separation of polymers in the base of

TABLE 2

Pumps and compressors

Symbol	Name of pump	Equipment specifications		Prime mover	
		Size	Type	Hp.	Type
J- 1	Crude charge	3x4x7½ 4 stage SD multiplex	centrifugal	100	non-condensing turbine
J- 2	Crude tower top reflux	3 in. L 1 stage "S"	centrifugal	30	
J- 3	Crude tower intermediate reflux	3x4x9 1 stage BM process	centrifugal	20	
J- 4	Naphtha	7½x6x10 duplex, valve plate, and cover	reciprocating		
J- 5	Kerosine	7½x5x12 duplex, valve plate, and cover	reciprocating		
J- 6	Light virgin gas oil	12x7½x16 single side pot	reciprocating		
J- 7	Heavy virgin gas oil	10x7x12 single side pot	reciprocating		
J- 8	Reduced crude	12x7½x20 single side pot	reciprocating		
J- 9	Straight run debutanizer bottoms	6x5½x6 duplex, valve plate, and cover	reciprocating		
J-10	Reforming furnace charge	14x4½x12 duplex outside end packed	reciprocating		
J-11	Viscosity breaker furnace charge	2 in. ATB 4 stage	centrifugal	150	non-condensing turbine
J-12	Gas-oil furnace charge	2½ in. ITB 6 stage	centrifugal	400	non-condensing turbine
J-13	Bubble tower top reflux	4x6x8 1 stage BM process	centrifugal	50	
J-14	Bubble tower intermediate reflux	4 in. HVTB 1 stage	centrifugal	150	
J-15	Polymer	6⅛x4½x12 single side pot	reciprocating		
J-16	Afterfractionator bottoms	6⅛x4½x12 single side pot	reciprocating		
J-17	Rich oil	2½ in. M 1 stage "S"	centrifugal	20	
J-18	Debutanizer charge and afterfractionator reflux	3x4x7½—2 stage SD multiplex	centrifugal	25	
J-19	Debutanizer reflux	3x4x9—1 stage BM process	centrifugal	30	
J-20	Clean gland oil return	6x4x6 duplex, valve plate, and cover	reciprocating		
J-21	Crude gas compressor	12x9 HB horizontal single		40	
J-22	Straight run debutanizer overhead	5x3½x10 single	reciprocating		
J-32	Poly feed charge	18x8x20 single	reciprocating		
J-33	Poly furnace charge	4⅝x18 triplex outside end packed	reciprocating	500	non-condensing turbine
J-34	Partial stabilizer reflux	2½x4x12—1 stage BM process	centrifugal	40	
J-35	Feed furnace stripper—H_2O reflux	3x4x9—1 stage BM process	centrifugal	20	
J-36	Feed furnace stripper—Refrigerant reflux	8x6x12 single	reciprocating		
J-40 J-40A J-57 J-57A	Gas compressors	GMR—4 (2) combination propane-refrigerant compressors		300	gas-engine driven
J-42	Casinghead stabilizer charge	2x3x7½—6 stage SD multiplex	centrifugal	60	
J-43	Casinghead stabilizer reflux	4x6x12—1 stage BM process	centrifugal	50	
J-44	Depropanizer	2x3x7½—6 stage SD multiplex	centrifugal	50	
J-45	Depropanizer reflux	3x4x9—1 stage BM multiplex	centrifugal	30	
J-55	Emulsion	8 in. L 1 stage S	centrifugal	200	non-condensing turbine
J-56	Settled acid oil	2x3x7½—4 stage SD multiplex	centrifugal	40	
J-58	Caustic recirculating	6x4x6 duplex, valve plate, and cover	reciprocating		
J-59	Spent acid	1½ GRS double helical gear	rotary	2	
J-60	Fresh caustic	5x3x6 single and valve plate cover	reciprocating		
J-61	Fresh acid	1½ GRS double helical gear	rotary	2	
J-62	Compressor condensate	10x8x20 single side pot	reciprocating		
J-63	Isobutane tower reflux	4x6x12—1 stage BM process	centrifugal	60	
J-64	Debutanizer tower reflux	2x3x7½—6 stage SD multiplex	centrifugal	40	
J-65	Pyrolysis furnace charge	12x4x12 duplex outside end packed	reciprocating		
J-66	Rerun tower reflux	6x4x6 duplex valve plate and cover	reciprocating		
J-67	Rerun bottoms pump	4½x3x8 single side pot	reciprocating		
J-68	Acid recirculation	1½ GRS double helical gear	rotary	3	
J-69	Sump pump	1½ BSROM vertical sump	centrifugal	1½	
J-70	Test (reversion quench)	14x2¼x12 single outside end packed	reciprocating		
J-71	Condensate from reboiler	C 43 No. OOKL 3 stage vertical	centrifugal	5	
J-72	Condensate from reboiler	C 27 No. OOOBKL 4 stage vertical	centrifugal	2	
J-73	Condensate return	No. OKH 5 stage vertical	centrifugal	7½	
J-74	Desuperheating water	8 in. 10 stage HC	centrifugal	5	
J-75	Instrument air compressor	7½x5½ vertical single stage	compressor	25	
J-76	Polymer gasoline recharging	8x5x12 single side pot	reciprocating		

North wing of main pump house, looking toward control room



the clay towers, the treated cracked gasoline then goes to the afterfractionator tower (E-8) in which remaining polymers formed in the clay towers, and heavy ends are removed. (The polymers are then returned to the evaporator).

The cracked gasoline (from which the polymers have been removed) from the afterfractionator tower after going through the high-pressure gas separator then goes to the cracked gasoline debutanizer tower (E-10) for the removal of propane and butanes (including butenes). The debutanized cracked gasoline from the base of E-10 is then blended with normal butane by means of a ratio controller, then is washed with caustic and allowed to settle. From the settling tank it is pumped to the liquid copper-treating plant and after treatment it is pumped to storage, ready for blending to produce motor-grade gasoline.

The overhead from E-10 goes to the depropanizer feed drum in the polymerization area of the plant.

Gas taken overhead from the high-pressure separator goes to the absorber tower (E-9). The primary absorption medium in the tower is gas-oil, continuously taken from the stripper tower through the absorber and returned to the intermediate section of the bubble tower. The absorber also receives gases removed from the cracked gasoline debutanizer reflux drum. Butane from the straight-run debutanizer is accumulated in the high-pressure gas separator.

The bottoms removed from the bubble tower constitute clean charging stock for the gas-oil coil in the 3-coil furnace. In the furnace, the stock passes through a primary preheater coil in the convection section, then is routed through the auxiliary exchanger, then through a secondary preheater coil in the convection (center) section in the furnace, then through additional tubes in the lefthand side of the furnace. The stock then joins the output of the viscosity-breaker coil and goes to the soaker drum.

From a "boot" on the side of the bubble tower, the intermediate reflux pump (J-14) takes gas-oil that is used for a variety of purposes as follows:

(1) Used for reboiling the afterfractionator tower.

(2) Used for reboiling the cracked gasoline debutanizer.

(3) Used for reboiling the alkylate rerun tower.

(4) Used as gland oil on pumps.

(5) Used as secondary absorption oil in the absorber tower.

(6) Used as evaporator and bubble tower reflux and quench.

After the oil has functioned in the above services it is returned to the bubble tower. All gland oil is returned to the bubble tower, except that portion used in the glands of the viscosity-breaker furnace charge pump. This oil, being contaminated, is returned to the evaporator.

Casinghead Stabilization

The PBC (propane-butane-casinghead) stock as received from the pipe line has a Reid vapor pressure of approximately 70 lb. per sq. in. It will be recalled that the crude oil produced at Ville Platte and Tepetate is stabilized in the field and the propane and butane are mixed with the casinghead gasoline for transportation to the Lake Charles refinery.

The 70-lb. stock enters the casinghead stabilizer tower (E-11) to be stabilized to either a 14-lb. or a 22-lb. natural gasoline, depending upon market requirements. The stabilized gaso-

(Continued on page 46)

TABLE 3

Pressure vessels

Symbol	No.	Name of vessel	I.D. after corrosion is added		Shell length		Total Height		Operating temperature of oil in vessel		Pressures, lb. per sq. in.			
			Ft.	In.	Ft.	In.	Ft.	In.	Top, F.	Bottom, F.	Operating	Design	Hydrostatic	Hammer test
k1	1	Crude tower	9	6	93	6	107	6	220	675	10	25	45	37
2	1	Stripper tower	3	6	55	6	67	6	270	580	10	25	114	95
3	1	Straight run debutanizer tower	3	0	33	0	38	0	125	255	35	50	119	99
4	1	Soaking drum	5	0	38	0	....	....	945	....	400	440	1254	1045
5	1	Evaporator tower	8	6	55	6	63	9	660	800	120	135	230	191
6	1	Bubble tower	8	0	53	6	67	6	400	620	120	135	262	218
7	2	Clay towers	12	0	16	0	....	....	490		115	130	215	179
8	1	Afterfractionator tower	6	0	27	6	39	6	385	470	110	125	227	189
9	1	Absorber tower	4	0	60	6	74	6	105	120	100	115	232	193
10	1	Debutanizer tower	4	6	73	0	78	0	150	400	135	150	278	231
11	1	Casinghead stabilizer tower	6	6	83	0	88	0	158	282	200	220	350	291
12	1	Depropanizer tower	5	0	73	0	78	0	135	225	300	330	536	443
13	1	Partial stabilizer tower	6	6	55	0	60	0	180	360	500	550	825	687
14	1	Furnace feed stripper	4	6	26	0	....	....	135	170	500	550	825	687
22	1	Isobutane tower	8	0	113	0	118	0	136	171	105	120	211	176
23	1	Alkylate debutanizer tower	4	0	61	0	66	0	142	326	80	95	178	148
26	1	Alkylate rerun tower	2	8	49	0	61	0	253	450	3	25	124	103
F1	1	Crude tower reflux drum	7	0	14	0	23	0	....	100	0	25	57	47
2	1	Dry drum	2	8	6	0	....	....	....	100	0	25	123	102
3	1	Condensate drum	2	8	6	0	....	....	....	100	35	50	123	102
4	1	Gland oil drum	2	8	6	0	....	....	....	150	100	115	261	217
6	1	High-pressure gas separator	6	0	13	0	....	....	....	90	110	125	219	182
7	1	Debutanizer reflux drum	5	0	15	6	....	....	....	100	135	150	280	231
11	1	Casinghead stabilizer reflux drum	6	0	17	0	....	....	....	120	200	220	350	275

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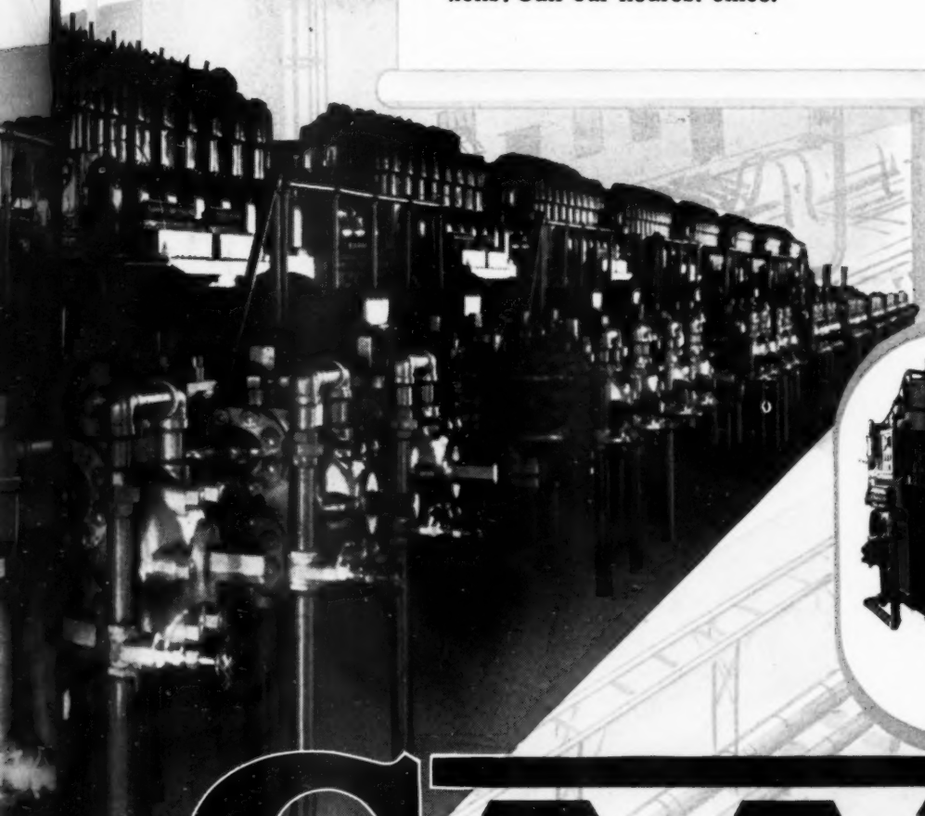

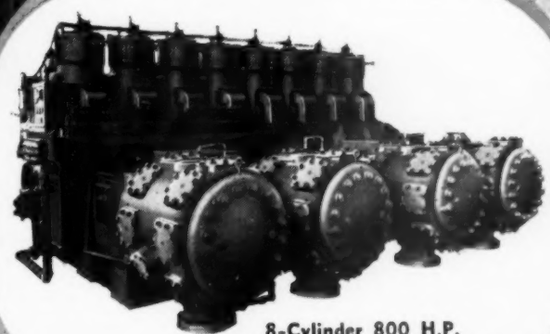

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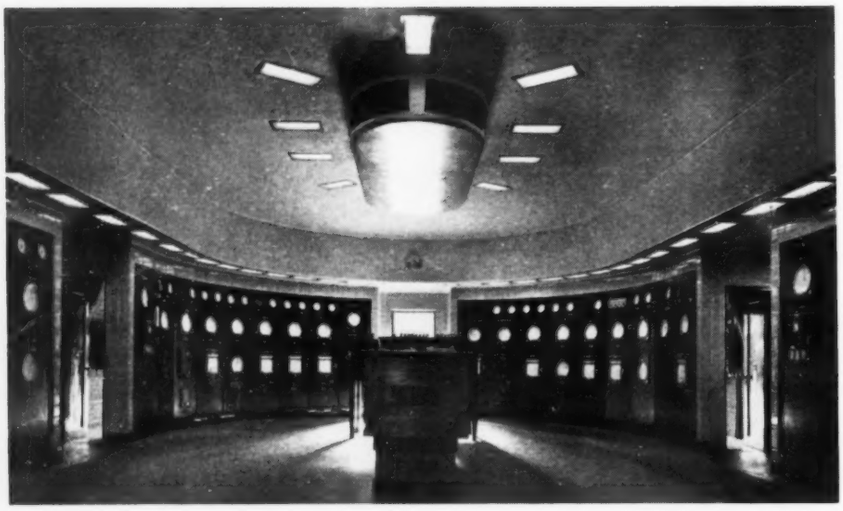

Obround control room in heart of processing area provides graphic centralized control of refinery

(Continued from page 43)

line is then pumped to storage without any sweetening required.

The overhead from E-11, consisting principally of propane, butane, and *iso*-butane, goes to the depropanizer feed drum. The total feed to the depropanizer feed drum is comprised of the following:

(1) Saturated hydrocarbons obtained from the PBC stock.

(2) Saturated and unsaturated hydrocarbons resulting from the cracking operations.

Polymerization Plant

From the depropanizer feed drum the charge goes to the depropanizer tower (E-12). The overhead from the depropanizer is propane that goes first to the poly feed drum, where it joins the butane from the alkylate debutanizer as charging stock for the thermal polymerization furnace.

From the furnace the stock goes through exchangers and reboilers to the partial stabilizer tower (E-13). The overhead from the partial stabilizer consists principally of propane and butane that was not polymerized. This overhead is recycled. Polymer distillate is drawn from the base of the partial stabilizer and is returned to the evaporator to be cleaned-up.

Alkylation Plant

The bottoms from the depropanizer tower are pumped direct to the alkylate reactor.

In the combination reactor and acid settler, the total material charged to the reactor is intimately mixed with 98 percent sulphuric acid. Makeup acid is injected into the oil-acid emulsion that is circulated continuously through the reactor.

After leaving the reactor, the reactor effluent is then neutralized by caustic wash. After the caustic wash, the reactor effluent is washed with water to remove any traces of caustic that might prove injurious to the equipment because of its tendency to form scale.

After the water wash, the reactor effluent goes to the *iso*butane tower (E-22), in which the *iso*butane is removed. The *iso*butane is returned to the system as recycle (to the reactor after a portion is used as reflux on the *iso*butane tower).

The *iso*butane tower bottoms go to the alkylate debutanizer so that butane may be removed. Butane from the alkylate debutanizer becomes the charge for the butane furnace and in addition is utilized in the following ways:

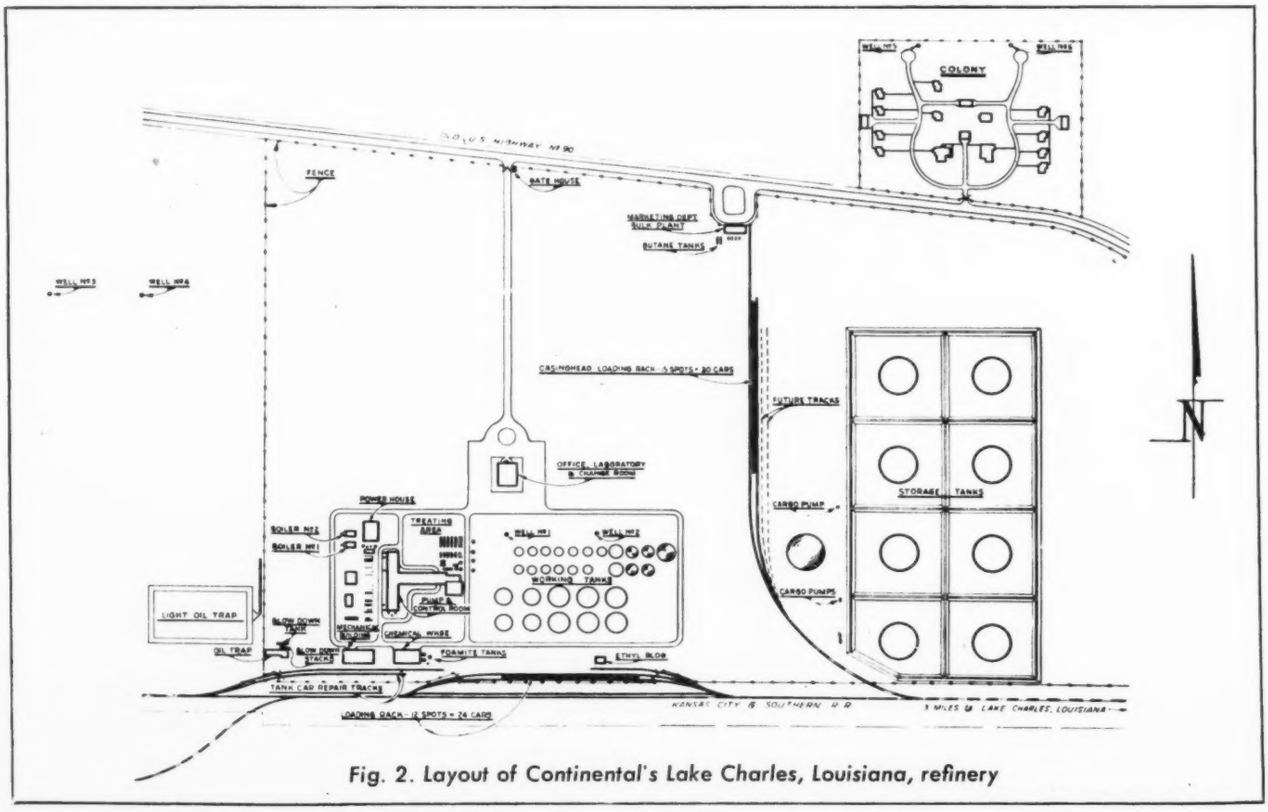

Fig. 2. Layout of Continental's Lake Charles, Louisiana, refinery

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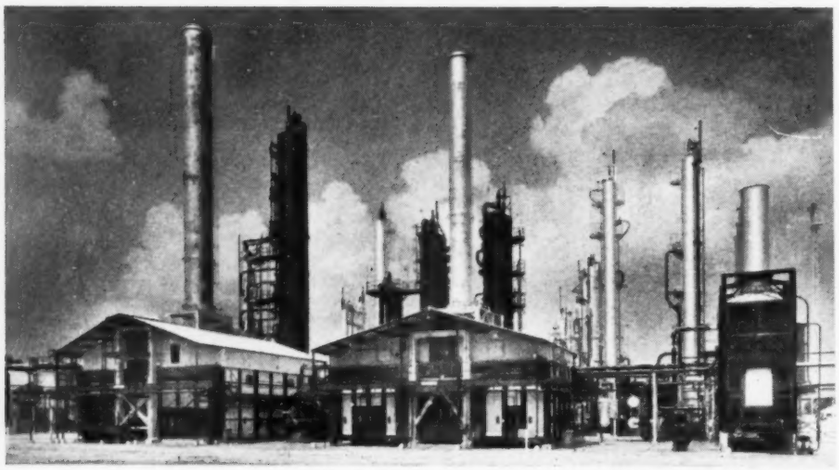

Reading from left to right: Combination 3-coil furnace, butane furnace, and thermal polymerization furnace

1. It serves as charging stock to the butane coil of the furnace.

2. It is fed to the poly feed drum as charge stock for the poly furnace.

3. It is used to blend with the cracked (pressure) gasoline.

The debutanizer bottoms then go to the alkylate rerun tower (E-24), in which the light and heavy alkylates are separated. The heavy alkylate is returned to the afterfractionator tower and the fraction boiling in the motor gasoline range then joins the cracked gasoline. The heaviest fraction becomes cracking stock.

Water, Steam, and Power

Water for the refinery is obtained from six wells drilled on the plant site. Three of these wells are each 250 ft. in depth; three are each 550 ft. deep. Each well is equipped with a submerged centrifugal pump driven by a 150-hp. motor. Capacity of each well is 2200 gal. per min. delivered at a pressure of 65 lb. per sq. in. and a temperature of approximately 72°F.

The water thus made available is relatively high in silica. The water analysis is approximately as follows:

	P.p.m.
$CaCO_3$	91
$MgCO_3$	29
SiO_2	23
R_2O_3	1
Na_2SO_3	18
Na_2SO_4	12
NaCl	58
Volatile and organic	98
Total solids	330
Suspended matter	light
CO_2	9

Water treatment. In selecting a water-treating process, the objective was to install not merely a water softener but, preferably, a water conditioner.

The type of equipment installed in the Lake Charles refinery employs lime and soda ash for the complete precipitation of all carbonates. From the water analysis, it is obvious that the silica concentration is sufficiently high to require the external reduction of silica. This is accomplished readily by the proper selection of chemicals. The original recommendation at Lake Charles for silica reduction was to feed magnesium sulphate. Alternative choices are to feed magnesium oxide or dolomitic lime. Magnesium oxide is being used currently. Provision is also made for recirculation of sludge, thereby effecting an important saving in chemicals.

Boiler plant. Steam at a pressure of 350 lb. per sq. in. is generated in two 1000-hp. boilers, each capable of developing 90,000 lb. of 620°F. (superheated) steam per hr. at 300 percent rating. These boilers differ from the usual type used in refineries, in that they are set outdoors, following the practice in setting furnaces and pipe stills.

An interesting and worthwhile improvement in boiler operation, added since the plant began operating, is the installation of automatic equipment controlling the speed of the motors driving the stack draft fans. As the boiler loads increase or decrease and the volume of fuel is varied accordingly, the change is reflected in the draft so that uniformly high combustion efficiency is now obtained automatically.

The total steam generated is distributed and utilized in the plant at three pressures: 350 lb., 150 lb., and 15 lb. per sq. in., respectively. All exhaust steam is trapped and returned to the boilers, thereby utilizing waste heat and materially reducing the volumes of makeup water and treating chemicals required.

Power Plant. Electric power for the refinery is generated in one of the most modern plants ever installed in a refinery of this size.

Two generators, each having a capacity of 2500 kva., 80 percent power factor, are direct-connected to two 3000-hp. steam turbines utilizing 350-lb. steam that is condensed to 28½-in. vacuum. The generators deliver the power at 2400 v., 3 phase, 60 cycle. Certain of the motors in the plant operate at this voltage but the greater number operate at 440 v.

Yields

In the modern refinery employing so many reforming and cracking reactions with the attendant increases in effective volumes of stock, it is difficult to express yields in terms of initial stock volumes. Likewise, the ability to increase or decrease the relative yields of various products almost without limit makes it difficult to say what the maximum yields of specific products might be.

Nevertheless, to orient the reader concerning approximate yields at the Lake Charles refinery, certain representative figures may be given.

Based on an initial daily charge of 10,000 bbl. of 40° A.P.I. crude oil and 6000 bbl. of 70-lb. PBC stock, the daily yields of the plant will be approximately 6000 bbl. of motor gasoline having an endpoint of less than 400°F. and an octane number of 78-80 (Research method); 500 bbl. of alkylate having an octane number of 93 (A.S.T.M.), and 4000 bbl. of 26-lb. (Reid vapor pressure) natural gasoline. In addition to the above products, approximately 25 percent of the crude volume charged to the plant may be withdrawn as distillates (kerosine, Diesel fuel, and other special burner oils and tractor fuels).

General

Water Disposal. All water used in the plant is disposed of through one of two systems.

(1) All water used in closed coolers and condensers is discharged through a main flume to a large open earthen settling pit of a sufficient capacity to provide a settling time of approximately 4 hours. Water discharged from the pit is entirely free of all contaminating substances, thus fully complying with the State of Louisiana's stringent regulations governing the pollution of waters entering the Gulf of Mexico.

(2) All other waste waters accumulated in the plant that normally contain varying amounts of oil are carefully gathered in a special disposal system. At considerable additional expense, an oil separator was installed, constructed in accordance with the design developed and approved by the sub-committee of the A.P.I. assigned to the problem of developing such a separator a few years ago.

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A Critical Analysis of the Application of the Back-Pressure Method in Studies of Gas Reserves

PART 2 (Concluded)

by J. William Ferguson, Assistant Gas Engineer,
Canadian River Gas Company

A photograph and biographical sketch of the writer can be found on page 34 of the September issue of *The Petroleum Engineer*, in connection with Part 1 of this article.

TO continue with White's method, we weight the values of Q for $\Delta P^2 = 10$ M. and 100 M. for each well by the percentage that well's open flow is of the total open flow of all six wells. These weighting percentages are as follows for the three cases:

Well	Case 1	Case 2	Case 3
A	0.157	0.424	0.604
B	0.532	1.288	1.507
C	1.806	3.716	3.813
D	6.129	10.098	9.578
E	20.798	25.523	24.058
F	70.578	58.951	60.430
	100.000	100.000	100.000

Carrying out the multiplication and addition for each of these cases results in the following totals for the weighted values of Q at 10 M. and 100 M.:

Case	Weighted Q at 10 M., M. cu. ft.	Weighted Q at 100 M., M. cu. ft.
1	7,995	77,830
2	7,098	68,163
3	7,182	69,134

Taking the difference between the logarithms of Q at 100 M. and Q at 10 M. results in what White calls the "weighted average exponent," thus:

Case 1

log 77,830 M. cu. ft. = 7.8911470
log 7,995 M. cu. ft. = 6.9028185
Difference = "n" = 0.9883285

Case 2

log 68,163 M. cu. ft. = 7.8335493
log 7,098 M. cu. ft. = 6.8511544
Difference = "n" = 0.9823949

Case 3

log 69,134 M. cu. ft. = 7.8396917
log 7,182 M. cu. ft. = 6.8562454
Difference = "n" = 0.9834463

The process then involves drawing a straight line through the point representing the weighted average value of ΔP^2 and the total open flow for each case, having the weighted average slope. This results in different values of the coefficient for all three cases, as shown in the following tabulation of the constants for each case:

	Case 1	Case 2	Case 3
Weighted Average P_f	450	275.656	100
Weighted Average ΔP^2 (M.)	202.5	75.986	10
Total Open Flow (M. cu. ft.)	286,918	106,021	16,548
Slope "n"	0.9883285	0.9823949	0.9834463
Coefficient "C"	1,634.06	1,700.52	1,927.35

The curve for Case 1 would indicate a total open flow of only 14,765 M. cu. ft. when the pressures equalized at 100 lb., or an error of 11.32 percent; the curve for Case 2 would indicate an open flow of 277,707 M. cu. ft. at virgin pressure conditions (error 3.21 percent), and a total open flow of 14,460 M. cu. ft. at 100 lb. (error 12.62 percent); whereas the curve for Case 3 indicates an original total of 318,819 M. cu. ft. (error 11.12 percent). These three curves are shown in Fig. 3.

The significance of these calculations is this: If, at any time during the life of these wells, a composite curve is drawn by White's method, it will be accidental if it agrees with a curve drawn either prior to or after it.

Briefly let us consider two other hypothetical cases to see whether this general conclusion is warranted.

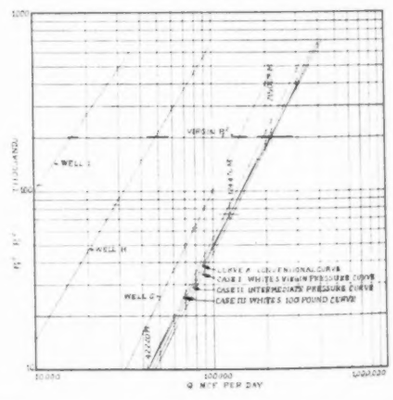
Example 3

Suppose we had six wells whose back-pressure curves are represented by the following values of "C" and "n"; whose virgin pressures (formation) were all 450 lb. per sq. in. absolute, and later equalized again at 100 lb., but whose pressures at an intermediate date are as shown:

Well	Coefficient "C"		Slope "n"	Intermediate pressure
G	316,228.0	$= 100{,}000\sqrt{10}$	0.5	250
H	31,622.8	$= 10{,}000\sqrt{10}$	0.6	290
I	3,162.28	$= 1{,}000\sqrt{10}$	0.7	330
J	316.228	$= 100\sqrt{10}$	0.8	370
K	31.6228	$= 10\sqrt{10}$	0.9	410
L	3.16228	$= \sqrt{10}$	1.0	450

The choice of coefficients may seem peculiar until it is noted that the logarithms of the coefficients are, respectively, 5.5, 4.5, 3.5, 2.5, 1.5, and 0.5. Without going through the calculations, we may point to the results, which can be verified by anyone wishing to do so. The conventional curve has curvature, of course, as in our previous example. The straight line drawn through the total Q at 10 M. and 100 M. has an "n" value of 0.5391320, and "C" = 294,436; log "C" = 5.4689902. Here again, the slope is controlled by the producing ability of the wells involved, and differs considerably from the arithmetical

Fig. 4. Illustrating the conditions in Example 3



average slope of 0.75. The curvature of the actual composite curve causes the following errors in using this straight line: at $\Delta P^2 = 25$ M., the error is + 0.38 percent; at 50 M., the error is + 0.30 percent; and at 200 M., the error is — 0.61 percent. Curve A of Fig. 4 is the true curve, but cannot be distinguished from the straight line.

Using White's method, the values of "C" and "n" for virgin, intermediate, and later pressure conditions are as follows:

	Slope n	C
Case 1 (virgin pressures)	0.5106123	419,805
Case 2 (intermediate pressures)	0.5114430	401,050
Case 3 (equalized 100 lb. pressures)	0.5076552	393,457

It will be noted from Fig. 4 that the intermediate pressure curve crosses the conventional curve at approximately the same point as the effective value of ΔP^2. The errors at points other than the weighted average formation pressures at the time the curves are drawn are quite large. The curve for Case 1 indicates a total open flow 9.64 percent too high for pressures at 100 lb.; that for Case 2 indicates a virgin total open flow 3.49 percent low and an open flow at 100 lb., which is 5.55 percent high; the curve for Case 3 indicates a virgin total open flow 9.60 percent too low.

Example 4

As our fourth and last hypothetical case, let us consider another group of six wells, having the same virgin and later equalized pressures of 450 lb. and 100 lb., respectively, and whose constants and intermediate pressures are as shown:

Well	C	n	Intermediate P_f
M	1,000	0.5	450
N	3162.28	0.6	370
O	10,000	0.7	290
P	10,000	0.8	250
Q	316.228	0.9	330
R	10	1.0	410

For this particular case, let us examine a little more closely the effect of curvature in the conventional composite curve. For this purpose, let us choose values of ΔP^2 such that the actual distances between them shall be approximately equal. In other words, the differences between the logarithms of successive values of ΔP^2 shall be nearly equal. To do this, let us space the values between 10 M. and 25 M. into four equal spaces; similarly between 50 M. and 100 M., and between 100 M. and 200 M. The last 12 spaces will be identical, but will be smaller than the first four. This spacing is, perhaps, not the best, because all the spaces are not exactly equal, and for this reason the results might be slightly different if equal spacing has been used throughout. The true curve is shown as Curve A of Fig. 5.

The method of least squares was used on the five points $\Delta P^2 = 10$ M., 25 M., 50 M., 100 M., and 200 M.; each of these spaces was then divided into two equal spaces, and the least squares calculation applied to the resulting nine points; and, finally, each of these eight spaces was divided into two equal spaces, resulting in 17 points, to which the method of least squares was applied. In addition, the straight line obtained by connecting the points at 10 M. and 100 M. was calculated. By these means, we have four different approximations to the actual curve, to which we shall refer as "5 point," "9 point," "17 point," and "2 point," respectively. The values for "C" and "n" for these four straight lines are:

Approximation	"C"	"n"
2 point	19,029.0	0.7770468
5 point	18,749.9	0.7784045
9 point	18,728.0	0.7784785
17 point	18,715.0	0.7785254

In the following tabulation of percentage of error at various values of ΔP^2, the intermediate values of ΔP^2 are shown as 12.5 . . . . to indicate that this value is only approximate. The logarithm in this particular case is the logarithm of 10,000 plus one-fourth of the difference between the logarithms of 25,000 and 10,000. The logarithm of 25,000 is 4.3979400; that for 10,000 is 4.0000000; consequently the logarithm of a point one-fourth the distance between these two points is 4.0994850.

It will be noted that the errors at ΔP^2 of 1000 and 1,000,000 for all four straight lines range from 1.65 percent to 2.83 percent, and that they are all negative. This means that whereas any one of these straight lines could be used for values between 10 M. and 200 M. with a maximum error of less than one-half percent, an attempt at extrapolation for values on either side of the chosen section will result in an increasing percentage of error the farther out we try to go. It will also be noted that the 17-point approximation is slightly more accurate for values in the neighborhood of 50 M., but that for values close to 10 M. and 200 M. the 5-point approximation is more nearly correct. It may be said, however, that for all practical purposes, the 5-point approximation will be sufficiently accurate, and is much more easy to calculate than the approximations for

ERROR IN CALCULATED QUANTITIES

ΔP^2 M.	Approximation: 2 point	5 point	9 point	17 point
	Error in percent			
1	— 2.21	— 2.74	— 2.81	— 2.83
10	0	— 0.22	— 0.28	— 0.30
12.5	+ 0.10	— 0.10	— 0.14	— 0.17
15.8	+ 0.18	+ 0.01	— 0.04	— 0.06
19.8	+ 0.22	+ 0.09	+ 0.04	+ 0.02
25	+ 0.26	+ 0.16	+ 0.11	+ 0.09
29.7	+ 0.27	+ 0.20	+ 0.15	+ 0.13
35.3	+ 0.26	+ 0.20	+ 0.16	+ 0.14
41.0	+ 0.25	+ 0.22	+ 0.18	+ 0.16
50	+ 0.22	+ 0.21	+ 0.18	+ 0.16
59.4	+ 0.18	+ 0.20	+ 0.16	+ 0.14
70.7	+ 0.13	+ 0.17	+ 0.14	+ 0.12
84.0	+ 0.07	+ 0.13	+ 0.10	+ 0.09
100	0	+ 0.09	+ 0.05	+ 0.04
118.9	— 0.09	+ 0.02	— 0.01	— 0.02
141.4	— 0.18	— 0.05	— 0.08	— 0.09
168.1	— 0.29	— 0.13	— 0.16	— 0.17
200	— 0.41	— 0.23	— 0.25	— 0.27
1000	— 2.03	— 2.12	— 1.65	— 1.66

9, 17, 35, or any greater number of points. The easiest calculation to make is the 2-point approximation, but it would seem from this example, as well as many others the writer has worked on, that the extra work in calculating the 5-point approximation is justifiable.

A word here about the use of the method of least squares in forcing a straight line through a group of points may be in order. Theoretically, this method could be used if the points were the pattern of shot-gun shot on a target, but the resulting straight line would be meaningless. Similarly, to attempt to use the method of least squares on a group of points best fitted by an algebraic curve of higher order than the straight line is likewise absolutely erroneous, unless a very short section of the curve is all that is of interest, and the amount of curvature in the chosen section is small enough to be negligible. If this latter condition exists, and a straight line is used, extension of the line any great distance in either direction from the section of curve it is to approximate is wholly unjustifiable, and may lead to the wildest sort of conclusions. A good illustration of this would be the use of a straight line to represent a small section of an arc of a circle of large diameter. So long as no attempt is made to extrapolate beyond the chosen section, the line may be fairly accurate, but it takes no imagination to see the conclusions that would be reached if such extrapolation were carried out beyond any reasonable limit. It cannot be too strongly emphasized that the method of least squares is a tool that has limitations, and that, like any other tool, these limitations must be recognized and observed if correct conclusions are to be reached.

For those who may be unfamiliar with the method of least squares, a brief explanation will be found in an appendix to this article.

To return to our last hypothetical example: The various straight lines drawn to approximate the composite curve for these six wells show effective intermediate formation pressures as follows:

Approximation	Effective P_f
2 point	268.686 lb. abs.
5 point	268.615
9 point	268.674
17 point	268.703

The weighted average intermediate formation pressure by White's method is 274.700 lb. abs., or a difference of more than 2 percent.

The composite curves obtained by White's method for the three formation pressure dates have the following constants:

	"C"	"n"
Case 1 Virgin pressures	16,057.4	0.7912844
Case 2 Intermediate	16,190.3	0.7883677
Case 3 All wells 100 lb.	17,206.8	0.7879759

The curve for Case 1 indicates a total open flow at 100 lb., which is 3.79 percent too low; the intermediate pressure curve (Case 2) shows an original total open flow 2.71 percent too low, and an open flow at 100 lb., 5.57 percent too low; the curve for Case 3 indicates an original total open flow 2.91 percent too high.

These four hypothetical cases show, beyond any possibility of doubt, that there is no consistency of results with Whites' methods. The percentage figures for the errors in each case would, of course, be changed if different curves had been used, or if different intermediate pressures had been chosen, but the general conclusions would be substantially the same.

It may be argued that the six wells chosen in each case are not fair samples of the distribution of slopes and open flows that might be found in a given field. Returning, however, to the principle developed in Example I that, if a group of wells all have curves of the same slope, the composite curve will have the same slope as the original curves, we could, then, consider that the curves we have chosen in each group for the largest wells could actually represent a number of wells, all having the same slope, and that the intermediate pressure chosen for those wells could be the effective formation pressures for the groups. Taking the last hypothetical case as an example, instead of calling each curve a single well, we could, instead, say that it is the curve for a group of wells, and that each of the wells in each group has the same coefficient and slope. The constants would then look something like this:

Group	Number of wells in group	Coefficient for individual wells	"n"
M	1	1000	0.5
N	5	632.456	0.6
O	10	1000	0.7
P	20	500	0.8
Q	5	63.2456	0.9
R	1	10	1.0

For the conventional method of calculating the composite curve, this group of 42 wells will give the identical curve as the original six wells, and the wells, individually, will have more nearly the same open flows. Moreover, the distribution of slopes is, perhaps, a little more in line with actual field experience. So long as each well in each group has the same intermediate formation pressure as the original well we considered, White's curves would be identical with those we developed for each case.

There does not seem to be any correlation between slope and open flow as encountered in actual gas wells, but the distribution of slopes seems to follow fairly closely a normal probability curve. Fig. 6 shows the pattern found in plotting the slope against the open flow for a group of 274 wells in five counties of the Texas Panhandle area. As can be seen, the pattern is purely of the shot-gun type, but when these same slopes are plotted as shown in Fig. 7, they reveal the probability nature of their distribution. The lighter line is drawn through the mid-point of each block of the stepladder graph to show the characteristics in a better fashion.

Another feature contained in White's article that should be called to the reader's attention is his method of arriving at an average back-pressure curve for a group of wells. Specifically, what he does is to multiply the open-flow for each well by its formation pressure; then, to get the weighted average formation pressure, as we have seen, he divides the sum of these products by the total open flow; he takes this same sum of the products and divides it by the sum of the formation pressures to arrive at the "weighted average open-flow." Through the point on the logarithmic graph representing the weighted average formation pressure and the weighted average open flow, he draws a line with the weighted average slope, derived as has been explained previously. There are a number of objections to this process, not the least of which is that it is very much similar to a person trying to lift himself by his own bootstraps. The very essence of a weighting operation is that one group of factors or the other is, of itself, incapable of giving

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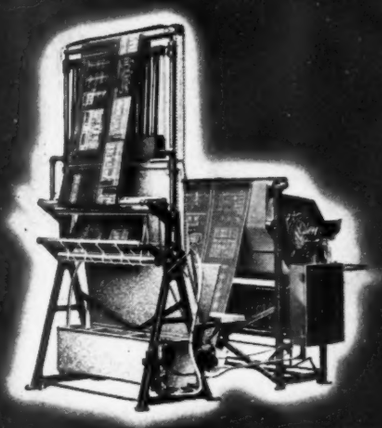

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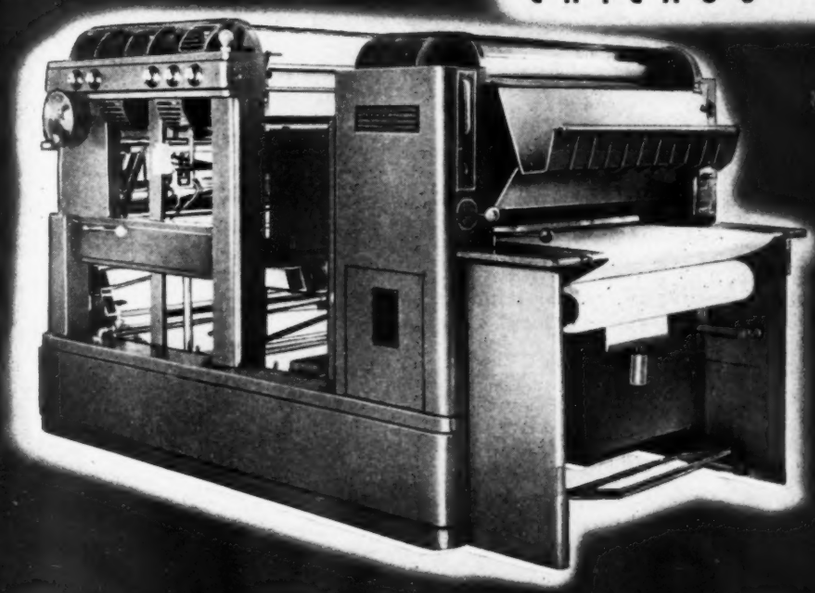

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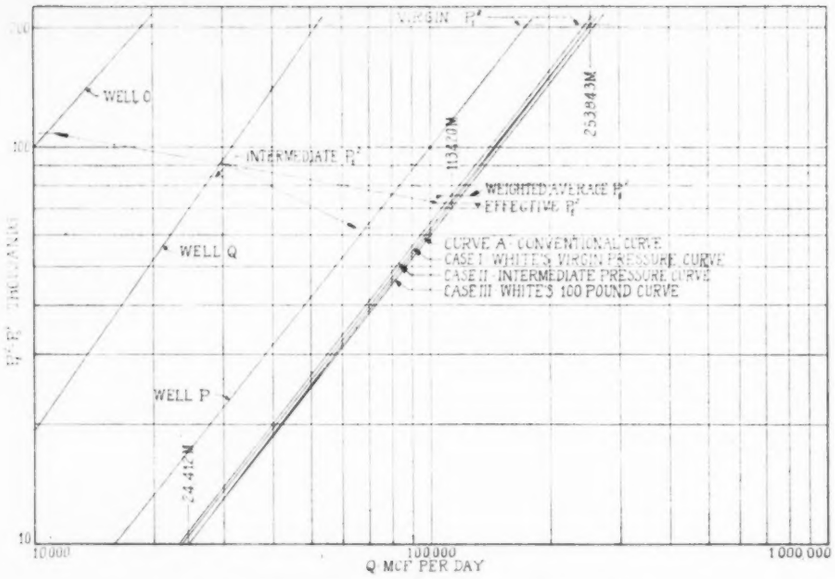

Fig. 5. Illustrating the conditions in Example 4

a true average when the sum of the group is divided by the number of items added. Having decided which group of factors needs weighting in order to give a true average, the use of that group to weight the other group is absolutely unsound practice.

In other words, if it is felt that a simple arithmetic average of the formation pressures does not give a true picture (and we have seen that it does not), but that the weighting of each individual formation pressure by its corresponding open flow should give correct results (and we have seen that this is also false), the weighting of open flows by corresponding formation pressures is totally unjustifiable, because, in the first instance, we question the value of the formation pressures, but accept the value of the open flows, whereas in the second instance, the reverse is true. If we attempt to weight in both directions simultaneously, we are at once believing and disbelieving the same data.

The only correct average curve that can be used to produce consistent results is a curve such that, for each value of ΔP^2 its Q value is exactly in the proportion to the Q value of the composite curve at that value of ΔP^2 which one well bears to the total number of wells. An average curve obtained in this way may be used wherever the whole group of wells is concerned, in exactly the same manner as the total curve, simply by multiplying the Q values of the average curve by the total number of wells in the group. A specific example may be in order here. In White's Table 1, he shows a total open flow of 77,451 M. cu. ft. and an average open flow of 18,978 M. cu. ft. for a group of four wells. The arithmetical average open flow is, of course, 19,363 M. cu. ft. Now, if we were interested in obtaining the allowable production from the group, we would actually have 19,363 M. cu. ft. allowable, while if we took White's average open flow, multiplied by 25 percent to get the allowable per well, and then multiplied by four to get the total for the group, we would have an allowable of only 18,978 M. cu. ft. The difference in this case is only about 2 percent, but this is only one example, and, as we have seen with the other functions, the amount of difference would depend entirely upon the other factors in the case, and the allowable figure could be either too high or too low.

By using the arithmetical average of the composite values, the average well curve will have the average open flow at the effective formation perssure for a given set of pressure conditions; furthermore, it is more likely to be a representative curve for future wells in the same general area than a curve that has no substantial excuse for its being.

Another error in judgment exhibited by White is his assertion, "In the past it has been customary for engineers and geologists . . . to estimate or assume an abandonment pressure. . . This estimated abandonment pressure has been arbitrary. . ." He proceeds to set forth the idea that, as the producing ability of the wells declines to a certain predetermined flow, they would be abandoned, regardless of remaining formation pressure, and in his example he shows one well being abandoned at 67.7 lb., whereas another in the same group of four wells is abandoned at 215.5 lb., but at the same value of the then absolute open flow. It seems that this is a much more arbitrary procedure than assuming an abandonment pressure, because, even though the 67.7-lb. well might have to be abandoned on account of the impracticability of compression, the well with 215.5 lb. could still produce some gas, even though it were a smaller amount than the arbitrarily chosen abandonment flow. This condition would continue until either the entire field was abandoned, or the amount of gas obtained from a well was insufficient to justify the expense of changing the charts or other routine operating costs, or until the well failed in some mechanical manner, such as caving.

White also thinks that the gas reserves underlying a given well should be used as a factor in determining the time when the abandonment flow, abandonment pressure, or any other pressure condition will be reached. Even if it is possible to determine accurately the original reserve per acre for a given tract of land, it still is almost an absolute impossibility to measure the amount of the original reserve that has been taken out of that particular tract because of subsurface drainage to areas of lower pressure; and when the pressure conditions in a permeably interconnected reservoir are unequal from point to point, it is not a matter of conjecture whether drainage is occurring, but the question is how much gas is moving.

There are fields in which a condition exists wherein a given well has a definite, fixed drainage area, and unless wells are drilled so close that interference between the drainage areas of two or more wells exists, a given well will produce only that amount of gas within its drainage area. Such fields are, however, the exception rather than the rule, and even in such fields a given well may have a drainage radius so large that several wells may be drilled within its area. In general, however, the mere fact that a pressure gradient exists across a reservoir is reason for assuming drainage to exist, unless considerable study has been made to show that this is not the case.

To say then, that there are so many millions of cu. ft. of gas underlying a given tract of land, and that a well on that tract will produce at a certain, predictable declining rate per year, and that at the end of so many years that well will have so depleted its reserve that its pressure will be such and such, while the well across the road, because it was not produced so heavily, or because it had more reserve to start with, will still have a 100 lb. or more greater

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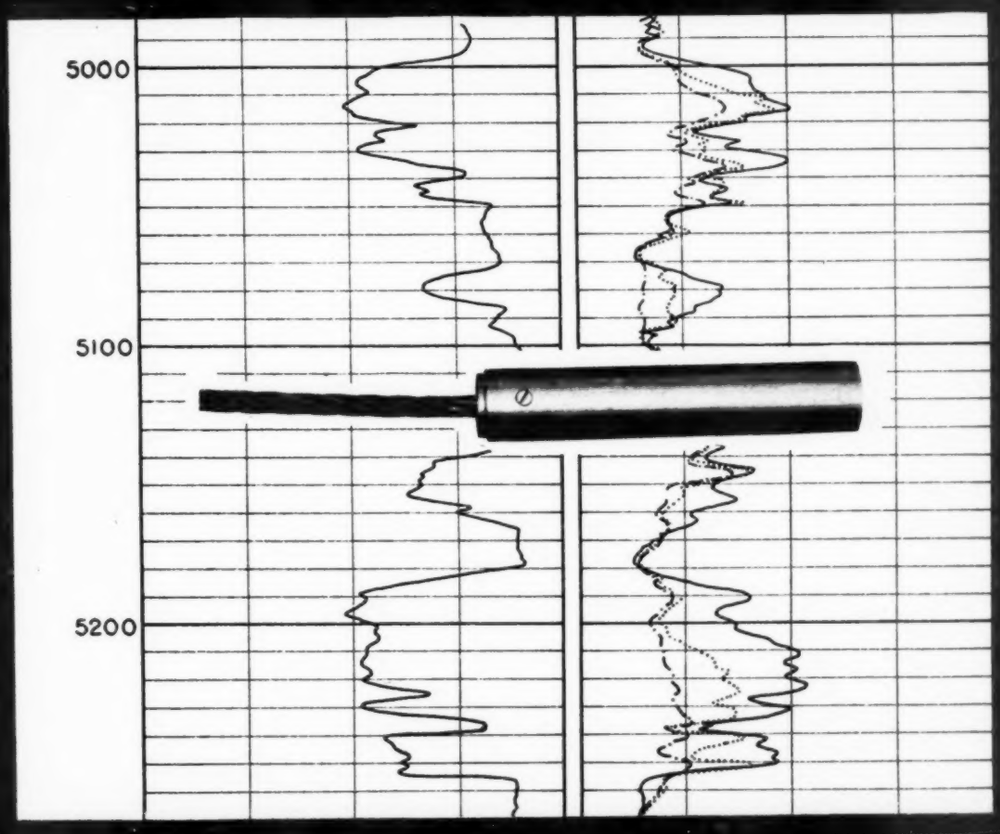


formation pressure remaining than the first well is just a little bit more than is justifiable unless specific and costly experiments are performed to determine without shadow of doubt that the two wells have no interconnection underground that would permit drainage of gas to occur.

There are one or two other phases of White's article with which exception could be taken, principally his assumption that any gas field will produce an equal volume of gas for every pound of pressure loss. It is a definite, provable fact that there are fields in which this is not the case, but to go into this subject in sufficient detail to establish these facts would require too much space, and really is beyond the scope of this article.

Summary

Four hypothetical cases have been chosen in which a range of values of "C" and "n" have been considered, such as would be likely to be encountered in actual practice. The composite curve has been calculated for each of these cases, and comparison made between the conventional curves and the curves obtained by White's methods. The errors in White's methods have been calculated for these four examples, which should be sufficiently general to cover the actual experience with well curves as to prove the basic errors in his work. If the intention had been merely to discredit the work, without offering any constructive ideas, the examples chosen could have been made so extreme that the errors resulting from White's method would have been almost ridiculous, but this was not the purpose of the article.

Appendix—The Method of Least Squares

The method of least squares is a mathematical device for obtaining a straight line that most closely fits a group of observed data points. It must be used with discretion, and its limitations must be recognized in a given case.

To apply the method to a group of points on log-log paper, one must use the logarithms of the values plotted, rather than the actual values.

The equation of a back-pressure curve, written in logarithmic form is:

$$\log Q = \log C + n \log \Delta P^2$$

If we adopt some sort of symbols for the three logarithms involved, say, $\log Q = U$, $\log C = K$, $\log \Delta P^2 = V$, the equation looks like this:

$$U = K + n V$$

which is the familiar form of the linear equation with two variables, U and V, and represents a straight line on ordinary coördinate paper. Now, if we have a number (N) of sets of points (U, V), and we wish to draw a straight line that will come as close as possible to fitting these points, the procedure is as follows: We tabulate the values of U and V; then for each set of these values we obtain the product U V, and also the square of the value of V. This tabulation looks like this:

Point No.	$U = \log Q$	$V = \log \Delta P^2$	$U \times V$	V^2
1				
2				
3				
.				
.				
.				
N				
	ΣU	ΣV	ΣUV	ΣV^2

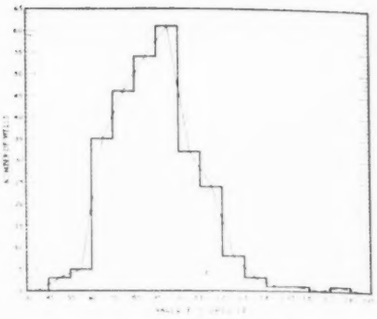
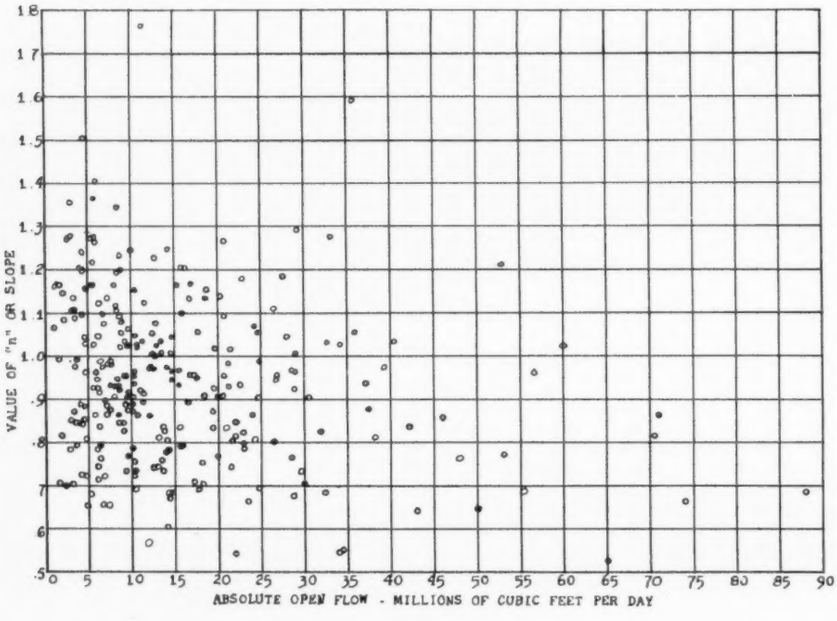


Fig. 7. The slopes of Fig. 6 plotted to reveal the probability nature of their distribution

Fig. 6. Pattern found in plotting the slope against the open flow for a group of 274 wells in Texas Panhandle area



The Greek letter Σ (sigma) is used to represent the summation of the variable appearing after it; that is, ΣUV is the sum of the products of each individual value of U by the corresponding value of V; ΣV^2 is the sum of the squares of the individual values of V.

The values of K and n for the best straight line are obtained by the following equations:

$$K = \log C = \frac{\Sigma U \, \Sigma V^2 - \Sigma V \, \Sigma UV}{N\Sigma V^2 - (\Sigma V)^2}$$

$$n = \text{slope} = \frac{N\Sigma UV - \Sigma U \, \Sigma V}{N\Sigma V^2 - (\Sigma V)^2}$$

It is very important to remember that the calculation of both of these constants K and n must be carried out. To calculate only one of them, and then solve for the other by substituting into the values (U, V) for one point, will give an erroneous result unless, by accident, the point chosen lies exactly upon the straight line determined by the values of K and n as calculated from the above equations. Of course, if the points all lie on a straight line to begin with, these calculations are unnecessary. ——☆☆☆——

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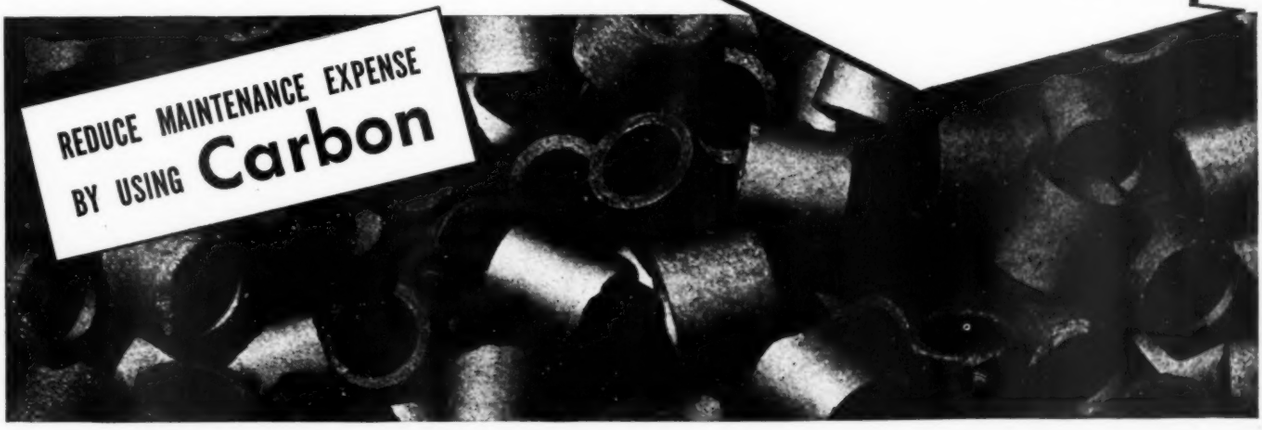

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Computing Gas Flow in Pipe Lines

PART 3—(Concluded)

by

P. McDonald Biddison

A photograph and biographical sketch of the writer can be found on page 51 of the August issue of The Petroleum Engineer in connection with Part 1 of this article.

APPENDIX I

The Viscosity of Gases

THE viscosities of mixed gases are not strictly in proportion to their composition, but they are closely enough in proportion for usual engineering estimates and may be calculated from the data on straight gases here cited. The viscosities of several natural gases from Technical Paper 555, U. S. Bureau of Mines, are also shown.

Viscosity of natural gases
(From Technical Paper 555, U. S. Bureau of Mines, "Viscosity of Natural Gas")

Gas no.	Composition percent					Specific gravity*	Actual Specific gravity†	Viscosity, lb. per sec. per ft. ×10⁸
	Methane	Ethane	Nitrogen	Carbon dioxide	Oxygen			
	Specific gravity							
	0.5543	1.04882	0.9674	1.5282	1.1053			
1	98.59	0	0.94	0.31	0.16	0.562	0.573	7.05
2	98.40	1.00	.50	.00	.10	.562	.562	7.14
3	96.67	2.64	.09	.31	.30	.572	.580	6.71
4	96.47	2.03	1.34	.00	.16	.571	.562	7.41
5	95.68	0.93	2.75	.16	.48	.574	.560	7.13
6	94.73	2.64	1.89	.30	.44	.581	.564	7.40
7	90.52	4.56	4.29	.21	.42	.599	.607	7.43
8	89.28	5.36	4.91	.15	.30	.604	.589	7.06
9	89.04	5.63	4.68	.21	.44	.606	.617	7.31
10	88.82	3.20	7.68	.16	.14	.604	.596	7.46
11	87.20	7.58	4.62	.30	.30	.615	.651	6.96
12	84.81	14.26	.63	.15	.15	.630	.627	6.46
13	82.86	16.51	.16	.31	.16	.641	.637	6.91
14	81.91	17.51	.11	.31	.16	.635	.634	6.87
15	77.50	14.70	7.50	.30	.00	.661	.690	7.00
16	75.92	10.76	3.41	8.81	1.10	.713	.720	7.57
17	73.96	24.89	.70	.15	0.30	.683	.672	6.74
18	69.90	21.10	8.60	.10	.30	.697	.695	7.26
19	67.27	24.43	3.91	3.45	.94	.730	.710	7.19
20	66.31	31.70	1.21	.47	.31	.723	.692	7.22
21	60.81	5.22	33.67	.15	.15	.721	.709	8.66
22	58.78	33.49	6.03	.77	.93	.757	.745	7.78
23	51.02	40.69	7.06	.31	.92	.793	.806	6.52
24	17.82	61.38	18.93	.77	1.10	.950	.962	8.05
25	2.38	88.57	6.70	.94	1.41	1.037	1.047	7.98

*The specific gravity has been computed from the chemical analysis given, which is combustion analysis except for No. 2 gas. (This gas is identified as No. 30 in Table 15, Monograph 6.) Technical Paper 555 gives the specific gravity for No. 2 at 0.562, No. 11 at 0.651, No. 15 at 0.690. As the analysis is combustion analysis, the combustibles being allocated to methane and ethane, the effect on specific gravity of the heavier hydrocarbons actually present is not truly reflected in the computation made from the analysis. The specific gravity shown is therefore to be considered only as a rough guide to show the tendency for viscosity to decrease with increase of specific gravity when the increase is caused by heavier hydrocarbons and to increase if the increase of specific gravity is caused by the noncombustible elements, nitrogen or carbon dioxide.

†Data supplied by W. B. Berwald, U. S. Bureau of Mines.

Viscosity of pure gases
(From Technical Paper 555, U. S. Bureau of Mines)

Gas	Reference	Viscosity x 10⁸ Lb./Sec./ft.
Air	23C Phys. Review Vol. 21	12.0
Nitrogen	23C Int. Critical Tables Vol. 5	11.63
Oxygen	23C Int. Critical Tables Vol. 5	13.43
Hydrogen	23C Int. Critical Tables Vol. 5	5.82
Helium	23C Int. Critical Tables Vol. 5	13.08
Methane	17C Int. Critical Tables Vol. 5	7.26
Ethane	23C Phys. Review Vol. 21	6.08
Propane	20C Aun. Phys. Vol. 10	5.30
Carbon Dioxide	23 Int. Critical Tables Vol. 5	9.64

Viscosity of butane
*(From Handbook of Liquefied Petroleum Gases—Western Gas)**

n-Butane	20C	4.97
IsoButane	20C	5.00
Propane	20C	5.42
Ethane	20C	6.24

Viscosity of carbon monoxide and carbon dioxide
*(From Chemical Engineers Handbook—Perry)**

Carbon Monoxide	9.07
Carbon Dioxide	10.62

*Note: Viscosity, metric units × 0.0672 equals viscosity English units, and viscosity English units × 14.881 equals viscosity metric units.

APPENDIX II

Small Pressure Drops

$$P_1^2 - P_2^2 = (P_1 + P_2)\ (P_1 - P_2) \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$\frac{P_1 + P_2}{2}$ is the average between inlet and outlet pressure and when the difference is small may be used as the mean pressure.

$$\text{Let } P_a = \frac{P_1 + P_2}{2} = \text{Average pressure} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$P_d = P_1 - P_2 = \text{Pressure drop} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Then from equation (8) of the main discussion:

$$Q = K\sqrt{\frac{2P_a \times P_d}{L \times f}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

$$= 1.4142 \times K \times \sqrt{P_a} \times \sqrt{\frac{P_d}{L \times f}} \quad . \quad . \quad . \quad . \quad (5)$$

For the conditions attending small pressure drops it is usually more convenient to express length in feet:

$$\frac{1}{5280} = L \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Also cu. ft. per hr. is a more convenient unit than the daily quantity:

$Q = 24\ Q_h$

Substituting these values:

$$24\ Q_h = 1.4142 \times \sqrt{5280} \times K \times \sqrt{P_a} \times \sqrt{\frac{P_d}{1 \times f}} \quad . \quad (8)$$

$$Q_h = 4.282\ K\sqrt{P_a} \times \frac{1}{\sqrt{f}} \times \sqrt{\frac{P_d}{1}} \quad . \quad . \quad . \quad . \quad (9)$$

$$\text{But} \qquad K = 38.7744\ \frac{T_o}{P_o}\sqrt{\frac{d^5}{GT}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

$$\text{Hence } Q_h = 166.03\ \frac{T_o}{P_o}\sqrt{\frac{d^5}{GT}} \times \sqrt{P_a} \times \sqrt{\frac{P_d}{1 \times f}} \quad . \quad (11)$$

If we make P_a equal to 14.735, equation (9) becomes

$$Q_h = 16.437 \times K \times \frac{1}{\sqrt{f}} \times \sqrt{\frac{P_d}{1}} \quad . \quad . \quad . \quad . \quad (12)$$

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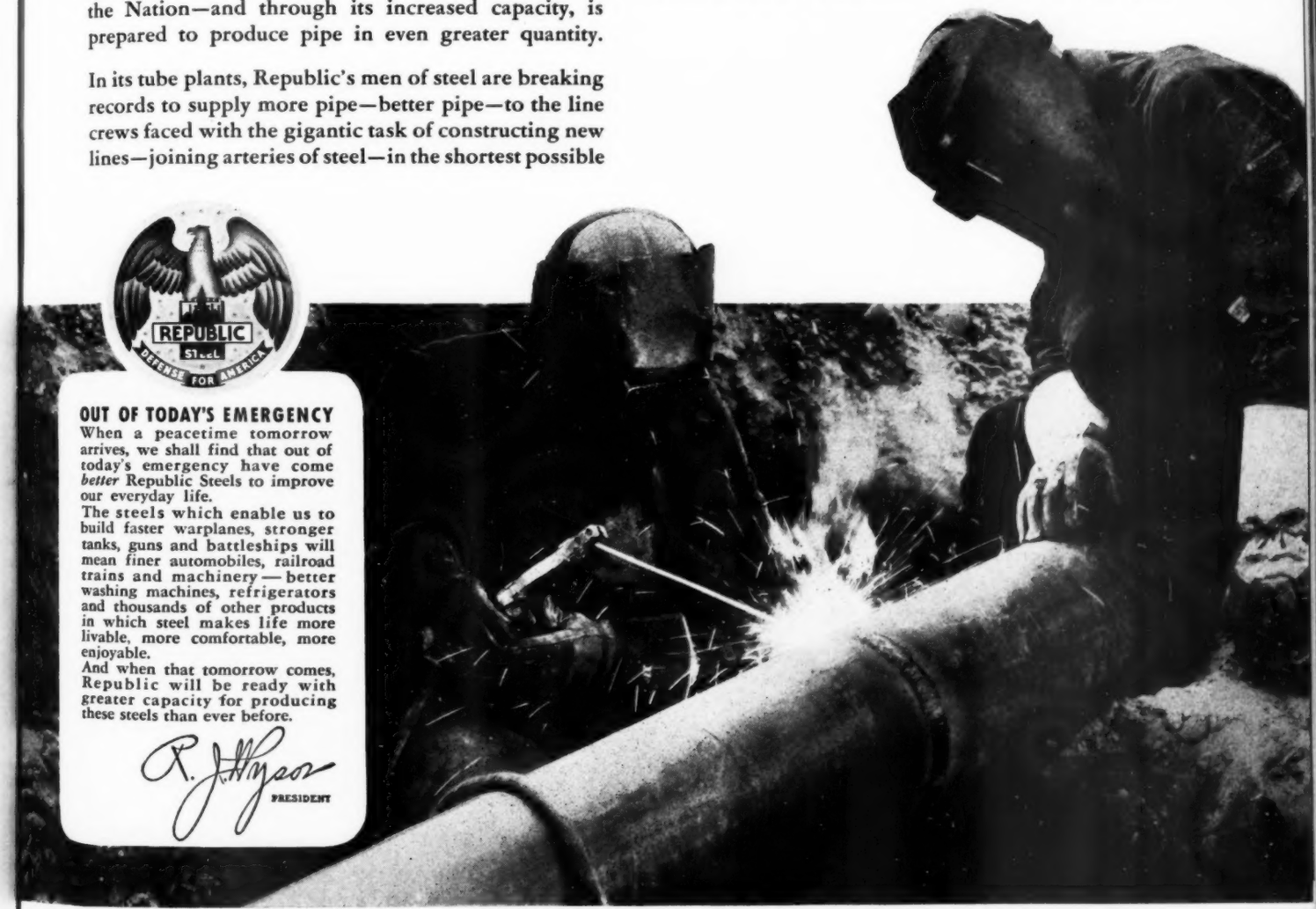

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TABLE 2

Values of $\sqrt{\frac{P_a}{14.735}}$

Inches abs.	Mercury vacuum	P_a Lb. abs.	$\frac{P_a}{14.735}$	$\sqrt{\frac{P_a}{14.735}}$
5	25	2.4550	0.1666	0.408
6	24	2.9462	.1999	.447
7	23	3.4374	.2333	.483
8	22	3.9286	.2666	.516
9	21	4.4198	.3000	.548
10	20	4.9110	.3333	.577
11	19	5.4022	.3666	.605
12	18	5.8934	.4000	.633
13	17	6.3846	.4333	.658
14	16	6.8758	.4666	.683
15	15	7.3670	.5000	.707
16	14	7.8582	.5333	.730
17	13	8.3494	.5666	.752
18	12	8.8406	.6000	.775
19	11	9.3318	.6333	.796
20	10	9.8230	.6666	.816
21	9	10.3142	.7000	.837
22	8	10.8054	.7333	.856
23	7	11 2966	.7667	.875
24	6	11.7878	.8000	.894
25	5	12.2790	.8333	.912
26	4	12.7702	.8667	.931
27	3	13.2614	.9000	.949
28	2	13.7526	.9333	.966
29	1	14.2438	.9667	.984
30	0	14.735	1.0000	1.000
		13.00	.8823	.9393
		13.05	.8856	.9410
		13.10	.8890	.9428
		13.15	.8924	.9446
		13.20	.8958	.9464
		13.25	.8992	.9482
		13.30	.9026	.9500
		13.35	.9060	.9518
		13.40	.9094	.9536
		13.45	.9128	.9554
		13.50	.9162	.9571
		13.55	.9196	.9589
		13.60	.9230	.9607
		13.65	.9264	.9625
		13.70	.9298	.9642
		13.75	.9332	.9660
		13.80	.9365	.9677
		13.85	.9399	.9694
		13.90	.9433	.9712
		13.95	.9467	.9729
		14.00	.9501	.9747
		14.05	.9535	.9764
		14.10	.9569	.9782
		14.15	.9603	.9799
		14.20	.9736	.9816
		14.25	.9671	.9834
		14.30	.9705	.9851
		14.35	.9739	.9868
		14.40	.9773	.9885
		14.45	.9807	.9903
		14.50	.9841	.9920
		14.55	.9874	.9936
		14.60	.9908	.9953
		14.65	.9942	.9971
		14.70	.9976	.9988
		14.75	1.0010	1.0005
		14.80	1.0044	1.0022
		14.85	1.0078	1.0039
		14.90	1.0112	1.0056
		14.95	1.0146	1.0073
		15.00	1.0180	1.0090
		15.10	1.0248	1.0124
		15.20	1.0316	1.0157
		15.30	1.0383	1.0190
		15.40	1.0451	1.0223
		15.50	1.0519	1.0256
		15.60	1.0587	1.0289
		15.70	1.0655	1.0322
		15.80	1.0723	1.0355
		15.90	1.0791	1.0388
		16.00	1.0859	1.0420
		17.00	1.1537	1.0741
		18.00	1.2216	1.1053
		19.00	1.2894	1.1355
		20.00	1.3573	1.1650
		21.00	1.4252	1.1938
		22.00	1.4930	1.2219
		23.00	1.5609	1.2494
		24.00	1.6288	1.2762
		25.00	1.6966	1.3025
		26.00	1.7645	1.3284
		27.00	1.8324	1.3537
		28.00	1.9002	1.3785
		29.00	1.9681	1.4029
		30.00	2.0360	1.4269
		31.00	2.1038	1.4505
		32.00	2.1717	1.4737
		33.00	2.2396	1.4966
		34.00	2.3074	1.5190
		35.00	2.3753	1.5412
		36.00	2.4432	1.5631
		37.00	2.5110	1.5846
		38.00	2.5789	1.6059
		39.00	2 6468	1.6269
		40.00	2.7146	1.6476
		41.00	2.7825	1.6681
		42.00	2.8504	1.6883
		43.00	2.9182	1.7083
		44.00	2.9861	1.7281

and equation (11) becomes:

$$Q_h = 637.32 \times \frac{T_0}{P_0}\sqrt{\frac{d^5}{GT}} \times \sqrt{\frac{P_d}{1 \times f}} \quad . \quad . \quad . \quad (13)$$

If the pressure drop be expressed in inches of water:

$$\frac{P_d}{27.68} = h \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

Substituting in (12) and (13):

$$Q_h = 3.124 \times K \times \frac{1}{\sqrt{f}} \times \sqrt{\frac{P_d}{1}} \quad . \quad . \quad . \quad . \quad (15)$$

$$Q_h = 121.14 \times \frac{T_0}{P_0} \times \sqrt{\frac{d^5}{GT}} \times \sqrt{\frac{P_d}{1 \times f}} \quad . \quad . \quad (16)$$

These equations may be used for calculations on distribution systems particularly. If P_a differs materially from 14.735, correction to equations (12), (13), (15), and (16) may be made by multiplying the answer by $\sqrt{\frac{P_a}{14.735}}$, values of which are given in Table 2.

Distribution Mains

If equal quantities be taken from a line at equal distances, a condition approached by distribution mains, and if Q_0 be the delivery at outlet, L the total length, n the number of taps, and m the fraction of Q_0 delivered at each side outlet, then:

$$\text{Input} = Q = Q_0 + n \times m \times Q_0 = Q_0(1 + nm) \quad . \quad (17)$$

The number of sections of line is $n + 1$.

Beginning at the outlet section of line, from equation (15) we derive:

$$\left(\frac{Q_0}{3.124\,K\frac{1}{\sqrt{f_1}}}\right)^2 \times \frac{1}{n+1} = P_{d_1} \quad . \quad . \quad . \quad . \quad . \quad (18)$$

$$\left(\frac{Q_0 \times (m+1)}{3.124\,K\,\frac{1}{\sqrt{f_2}}}\right)^2 \times \frac{1}{n+1} = P_{d_2} \quad . \quad . \quad . \quad . \quad . \quad (19)$$

$$\left(\frac{Q_0 \times (2m+1)}{3.124\,K \times \frac{1}{\sqrt{f_3}}}\right)^2 \times \frac{1}{n+1} = P_{d_3} \quad . \quad . \quad . \quad . \quad (20)$$

$$\left(\frac{Q_0 \times (nm+1)}{3.124\,K \times \frac{1}{\sqrt{f_n}}}\right)^2 \times \frac{1}{n+1} = P_{dn} \quad . \quad . \quad . \quad . \quad (21)$$

As the sum of the drops $= P_d$ then if we assume a mean value for $\frac{1}{\sqrt{f}}$:

$$\left[\left(\frac{Q_0}{3.124\,K\frac{1}{\sqrt{f}}}\right)^2 + \left(\frac{Q_0 \times (m+1)}{3.124\,K\,\frac{1}{\sqrt{f}}}\right)^2 + \left(\frac{Q_0 \times (2m+1)}{3.124\,K\,\frac{1}{\sqrt{f}}}\right)^2 + \cdots \left(\frac{Q_0 \times (nm+1)}{3.124\,K\,\frac{1}{\sqrt{f}}}\right)^2\right] \times \frac{1}{n+1} = P_d \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (22)$$

$$\left(\frac{Q_0}{3.124\,K\,\frac{1}{\sqrt{f}}}\right)^2 \times \frac{1}{n+1} \times \left[(n+1)(nm+1) + \frac{nm^2}{6}(n+1)(2m+1)\right] = P_d \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

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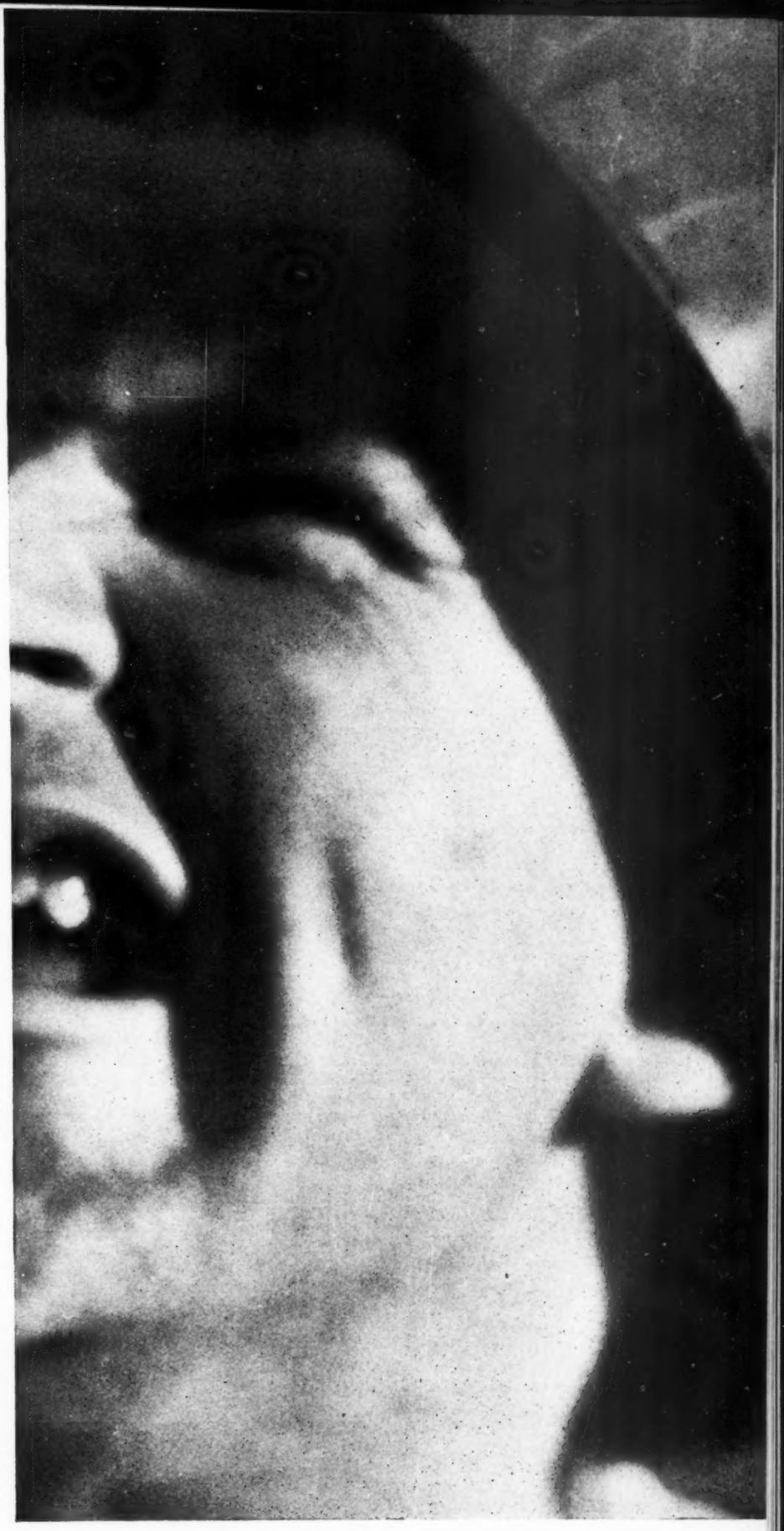

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APPENDIX III

The Effect of Deviation from Boyle's Law

The general equations for flow of gas in pipe lines assume that the gas follows Boyle's Law. Many of the constituents of commercial gases deviate markedly at high pressures from Boyle's Law, however, as do the pure gases, the amount of deviation varying with the different gases and being a function of temperature and pressure. To determine the effect of deviation upon flow in pipe lines it is necessary to begin with the fundamental equations of the pressure-volume relationship and energy in the flowing stream. The fundamental equation, $pv = RT$, for a gas that obeys Boyle's Law becomes, $pv\lambda = RT$, for those gases that deviate from Boyle's Law; λ being the deviation at pressure p, expressed as a number, not as a percentage. The data on deviation of natural gas reported by U. S. Bureau of Mines in Monograph 6, Technical paper 555, and Technical Paper 539, when plotted on logarithmic coördinates with percent deviation against absolute pressure, become straight lines within the range of the experiments. The equation of such lines is:

Deviation (percent) $= 100 \times aP^n$,

with pressure in lb. per sq. in. from which, inasmuch as the deviation expressed as a ratio $= \dfrac{100 + 100aP^n}{100}$, we derive:

$\lambda = 1 + aP^n$.

The data on compressibility of pure gases indicate that for most natural gases such relationship will hold to near 2000 lb. Taking as example Gases No. 30, 33, and 34 of Monograph 6, U. S. Bureau of Mines, the values of a and n determined for the equation $\lambda = 1 + aP^n$ are shown in Table 3.

TABLE 3

Sample No. from U. S. Bureau of Mines:			Values of a	Values of n
Monograph 6 Tables 15 and 16	Technical Paper 555 Table 3	Technical Paper 539 Table 2		
32		3	0.0000545	1.162
30	2	16	0.0000605	1.127
33		1	0.0000681	1.132
34		2	0.0000956	1.137
35		14	0.0000560	1.126

If we begin with the expression of Bernoulli's theorem (as given in equation (1), page 86 of Monograph 6[1]) that the total energy of the flowing stream is constant at all cross-sections, except for the energy loss in overcoming friction, and assume a horizontal line, we may calculate a correction factor for deviation. The calculations are too lengthy to incorporate herein, but the result is:

$$C_d = \sqrt{1 + \frac{2a}{n+2} \times \frac{P_1^{n+2} - P_2^{n+2}}{P_1^2 - P_2^2}} \quad . \quad . \quad . \quad . \quad (1)$$

Flow calculated without correction for deviation is to be multiplied by the above correction factor. In equation (8) of the main discussion:

$$Q = C_d \times K \times \frac{1}{\sqrt{f}} \times \sqrt{\frac{P_1^2 - P_2^2}{L}} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

In C, n is close to 1.0 and $n + 2$ is nearly equal to 3. The expression $\dfrac{2}{n+2} \times \dfrac{P_1^{n+2} - P_2^{n+2}}{P_1^2 - P_2^2}$ is similar to that for mean pressure in a flowing line where:

$$P_m = \frac{2}{3} \times \frac{P_1^3 - P_2^3}{P_1^2 - P_2^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

This derivation is given in Appendix V.

Hence we may use as an approximation, that is probably as accurate as any of the data to be used, the expression:

$$C_d = \sqrt{1 + bP_m} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Here bP_m is the deviation, expressed as a decimal fraction (not as a percent) at the mean pressure. The factor, b, may be the deviation per lb. of pressure on a straight line assumption or bP_m, the total deviation at the mean pressure, may be otherwise determined by plats from tests or by the methods of determination shown by Brown and Holcomb.[11]

APPENDIX IV

The Effect of Difference in Elevation

If we begin with the expression of Bernoulli's theorem (as given in equation (1), page 86 of Monograph 6[1]) and assume that the gas obeys Boyle's Law, we may derive:

For downward flow:

$$Q = K \times \frac{1}{\sqrt{f}} \times \sqrt{\frac{s}{e^s - 1} \times \frac{(P_1^2 \times e^s - P_2^2)}{L}} \quad . \quad (1)$$

This will solve the problem of pressure drop in input wells for repressuring by making $H = 5280 \times L$.

For upward flow:

$$Q = K \times \frac{1}{\sqrt{f}} \times \sqrt{\frac{s}{e^s - 1} \times \frac{(P_1^2 - P_2^2 \times e^s)}{L}} \quad . \quad (2)$$

This will solve for pressure drop in tubing or casing of a producing well by making $H = 5280 \times L$.

In these equations,

$$s = \frac{2H}{RT} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

in which,

H = head in ft.

R = gas constant $= \dfrac{53.33}{G}$

T = Temperature, °F., absolute

e = Base of Naperian logarithms = 2.71828

The equivalent of equation (2) has been developed by Ferguson,[12] using the Weymouth equation. He has shown that for a continuous line with rises and dips the equation may be written:

$$Q = K \times \frac{1}{\sqrt{f}} \times \sqrt{\frac{P_1^2 - P_2^2 \times e^z}{L_e}} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Here L_e is an equivalent length obtained by dividing the line into sections of relatively uniform slope, multiplying each length by the value of $\dfrac{e^s - 1}{s}$ corresponding to the elevation change in the section and taking the algebraic sum of the products. In this process H is positive for upward flow and negative for downward flow. The function z is the algebraic sum of individual values of s for the same sections. Using these values equation (4) may be solved in the same manner as for the general equations in the general discussion.

The same result may be obtained using positive values of H for both upward and downward flow if for the downward flow sections we substitute

$\dfrac{e^s - 1}{e^s \times s}$ for $\dfrac{e^s - 1}{s}$, and $\dfrac{1}{e^s}$ for e^s.

APPENDIX V

Mean Pressure

Ignoring the effects of deviation from Boyle's Law, the flow equation (No. 8 in the principal discussion), is:

$$Q = K\sqrt{\frac{P_1^2 - P_2^2}{L_1 \times f}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

(Continued on Page 67)

(Continued from Page 64)

At any point at distance L from the inlet where pressure is P the same value of Q is found from:

$$Q = K\sqrt{\frac{P_1^2 - P^2}{L \times f}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

From (1) and (2):

$$P = \sqrt{P_1^2 - \frac{P_1^2 - P_2^2}{L_1}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

If we consider a curve of pressure vs. length and take a strip of increment length its area is P*d*L. The total area under the curve is:

$$\text{Area} = \int_{L=L_1}^{L=o} P\,dL = \int_{L=L_1}^{L=o} \sqrt{P_1^2 - \frac{P_1^2 - P_2^2}{L_1}} \times dL$$

$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

$$= \frac{2}{3} \times L_1 \times \frac{P_1^3 - P_2^3}{P_1^2 - P_2^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The mean height is the area divided by the length:

$$P_m = \frac{2}{3} \times \frac{P_1^3 - P_2^3}{P_1^2 - P_2^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

In solution of equation (6) it is convenient to express P_2 in terms of ratio to P_1:

$$\text{Let } \frac{P_2}{P_1} = r \text{ or } P_2 = P_1 \times r \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

$$P_m = \frac{2}{3} \times \frac{P_1^3(1 - r^3)}{P_1^2(1 - r^2)} = \frac{2}{3} P_1 \times \frac{1 - r^3}{1 - r^2}$$

$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

APPENDIX VI

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P 061.
P 683.32

Simple Device to Aid Field Men In Making Repeated Multiplications

A SIMPLE device that some field men use but which may not have occurred to others is an aid in making repeated multiplications that involve a constant.

For example, assume that a production engineer has two orifice meters on a lease and it is necessary for him to make repeated calculations at the meters several times a day in order to determine the volume of gas metered. One of the meters has a coefficient of 2017 and the other meter has a coefficient of 9588.

Inasmuch as these constants will enter into every calculation made, multiplications involving these constants may be simplified by preparing brief tables as in the accompanying illustration.

By listing the products of the constant times 1, 2, 3, 4, 5, 6, 7, 8, and 9, respectively, multiplication may be reduced to addition as illustrated in the following example:

On the meter having a coefficient of 9588, which is the hourly coefficient in cu. ft., the product of the square roots of the differential and static pressures, respectively, is 4.89. What is the volume of gas metered?

Solution: Referring to the loose-leaf sheet illustrated, the products of each of the three numbers in the extension factor would be set down in reverse order.

From the table:

9 × 9588 =	86292
8 × 9588 =	76704
4 × 9588 =	38352
	46885.32 cu. ft.

Inasmuch as the greater number of mistakes occur in the multiplication process, the field man will find that his answers are more accurate when addition is all that is required.

Coefficient Calculations

Meter No. A-1	Meter No. A-2
Plate Size 2-7/8 x 4	Plate Size 6-1/2 by 10
Coefficient 2017	Coefficient 9588
1 x 2017 = 2,017	1 x 9588 = 9,588
2 x 2017 = 4,034	2 x 9588 = 19,176
3 x 2017 = 6,051	3 x 9588 = 28,764
4 x 2017 = 8,068	4 x 9588 = 38,352
5 x 2017 = 10,085	5 x 9588 = 47,940
6 x 2017 = 12,102	6 x 9588 = 57,528
7 x 2017 = 14,119	7 x 9588 = 67,116
8 x 2017 = 16,136	8 x 9588 = 76,704
9 x 2017 = 18,153	9 x 9588 = 86,292

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Subsurface Pressure Recorders and Equipment

PETROLEUM ENGINEER Exclusive Feature

☆ **Details of the instruments and equipment used and the field procedure and practices followed by the Kettleman North Dome Association, California, in making subsurface pressure surveys**

by Henry G. Abadie

Senior Petroleum Engineer, Kettleman North Dome Association

SUBSURFACE pressure data are essential in the analyses of many problems related to oil and gas production.[1] They are especially valuable in the study of reservoir characteristics and numerous phases of pump and well performance.

A program of systematic subsurface pressure surveys in a field should aim at accuracy. To insure accuracy, and thus a better interpretation of the field data obtained, reliable instruments and equipment and their intelligent use are necessary.

It is the purpose of this article to describe in some detail the instruments and equipment used and to discuss the procedure and practices followed by the Kettleman North Dome Association in making subsurface pressure surveys.

Since the inception of subsurface pressure surveys in the Kettleman Hills North Dome field in 1932, the two major operators there have used the Standard Depth Pressure Recorder almost exclusively. Initially, limited use was made of a pressure thief, or a maximum pressure gauge, by the Kettlemen North Dome Association.[2]

This was a shop-made pressure bailer fitted with an outwardly operative check valve and a pressure gauge connection. Its use provided the operator with a knowledge of well conditions that aided in outlining the specifications that would be required of a commercial instrument.

The Standard Depth Pressure Recorder is a continuous pressure recording instrument that has provisions for including a maximum recording thermometer. It is comparatively rugged for field operations and the accuracy required necessarily demands that it be carefully handled. To attain the maximum accuracy of 0.25 percent[3] and to yield consistent results adherence to certain rules is essential.

HENRY G. ABADIE

is a graduate of the University of California with a B.S. degree in petroleum engineering, 1936—Entered the employ of the Kettleman North Dome Association immediately after graduation and has been continuously employed by the Association since that time—Has been engaged in engineering work in various capacities in the production and petroleum engineering departments—At present is senior petroleum engineer.

Details of Depth Pressure Recorder

Pressure admitted through the inlet port of the footpiece acts upon the end of the spring plunger and causes the extension of the spring, see Figs. 1 and 2. A stylus attached to the upper or free end of the spring records its extension on the longitudinal axis of a chart contained in a drum. Rotation of the chart drum by means of a thermal motor or clock causes the stylus to be drawn laterally across the chart. The resultant trace of the stylus provides a record of pressures that may be correlated with the depths at which they were obtained

The Association's operating practice is to run a combination mercury-filled sinker bar and thermometer well with the instrument. This assembly weighs 29 lb. and is 92 in. in length overall and has an O.D. of 1¼ in. The mercury-filled sinker bar is not standard equipment as supplied by the manufacturer. In lieu of a sinker bar some operators run recorders in tandem, thereby obtaining check records, or at least one record should the other for any reason be illegible. The instrument is easily and quickly assembled and disassembled. All pressure joints are of permanent bronze-to-steel fit.

The spring assembly consists of:

1. Spring
2. Plunger
3. Upper and lower thimbles
4. Piston extension rod
5. Stylus rod

Interchangeable springs are available for seven ranges of pressure up to 7500 lb. per sq. in. Each spring is designed to have a maximum deflection of 5 in. Spring lengths and sizes vary according to range, but the overall length of the assembly from the end of plunger to stylus point is the same. The thimble at the lower end of the spring is stationary and the plunger is free to move through it. Screwed to the ¼-in. stainless steel plunger is a ⅜-in. rod acting as an extension; this in turn screws into the upper thimble, which is free to slide. By adjustment, this change in rod size provides a shoulder, which prevents the spring from pulling itself to a point of zero initial strain. Screwed to the other end of the upper thimble is the stylus rod, to which the stylus is fastened.

[1] "Development and Application of Subsurface Pressure Data in Kettleman Hills" by E. W. McAllister, *A.I.M.E. Petroleum Technology*, March, 1941.

[2] "A Consideration of the Use of Pressure, Temperature and Sampling Instruments for Subsurface Work in Kettleman Hills and the Possible Application of Data Thus Acquired to Production and Drilling Procedure," by C. L. Clark and C. B. Kimberlin. Presented at the A.P.I. Spring Meeting, 1933, Los Angeles, California.

[3] "Tests of Subsurface Pressure Recorders," by B. P. Kantzer and E. G. Trostel, A.P.I. Production Bulletin No. 218.

Percent deviations calculated $= \frac{\text{difference from mean probable press.}}{\text{maximum press. range of the element}} \times 100$

As the instrument is subjected to considerable vibration during operation it is advisable to check frequently for loose connections, checking with particular care the joints of the spring assembly. Both the stylus arm and the piston should be checked to see that they remain tightly screwed into place. If the stylus arm becomes loose it will be noted by a wide trace on the chart. The ends of the spring should be checked on the thimbles, as there is a tendency to unscrew. This may be taken care of, however, by spot-welding both ends of the spring to their respective thimbles. As this is a precaution against the unscrewing of the spring a very small bead of metal judiciously placed will suffice. As the plunger and spring shaft may become bent in handling, it is quite important that piston alignment be checked. If any eccentricity exists the condition must be remedied, as a bent plunger will introduce additional friction in the instrument and result in erratic readings. The plunger must be free of any pitting, scoring, or corrosion. Frequent polishing of the plunger with a piece of crocus cloth minimizes the friction between it and the C-cup packing. The spring assembly is mounted in the instrument by screwing it into the double-pin sub that serves as a bottom plug. The spring should never bear any of the stress of assembling. A stop screw on the end of the plunger prevents over-travel if the pressure range of the spring is exceeded.

The lower end of the double-pin sub has a recessed seat for the synthetic rubber C-cup, which provides the pressure seal in the instrument. In the selection of the cup some attention should be given to fit, i.e., one should be chosen that has a close fit, yet is free to move on the plunger. When frequent failures of the cup occur, the fault may lie in the bronze bushing,

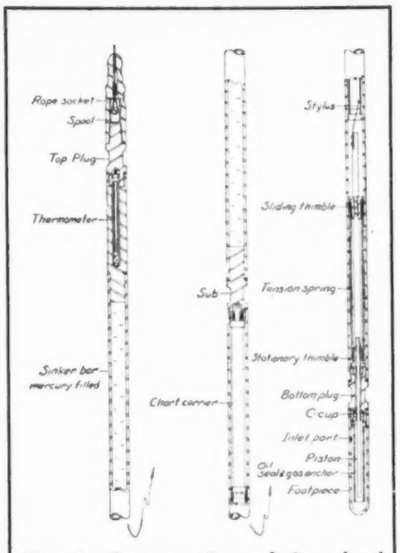


Fig. 1. Cross-section of Standard Depth Pressure Recorder

which may have become dislodged and pushed forward by the end of the plunger in mounting the spring. If this proves to be the case, it is then advisable to replace the sub. After some use the cup no longer fits the plunger closely and a seal is effected only by virtue of the impact action of the pressure on the lips of the cup. For this reason it will be found that cup failure will occur more frequently while running in open hole.

Screwed to the lower end of the bottom plug is the oil seal or gas anchor tube, which also acts as a retaining nut for the C-cup; also screwed to the lower end of the bottom plug, outside the oil seal tube, is the footpiece. In operation, the footpiece is filled with castor oil, which was found best suited for the particular requirements. In filling the footpiece, care should be taken to exclude air bubbles. The principal function of the gas anchor in conjunction with the castor oil is to insure proper lubrication by preventing gas from coming in contact with the C-cup. Should gas accumulate at the top of the oil and against the cup, it would cause a partial loss of pressure seal and drying of the cup with an increase in friction.

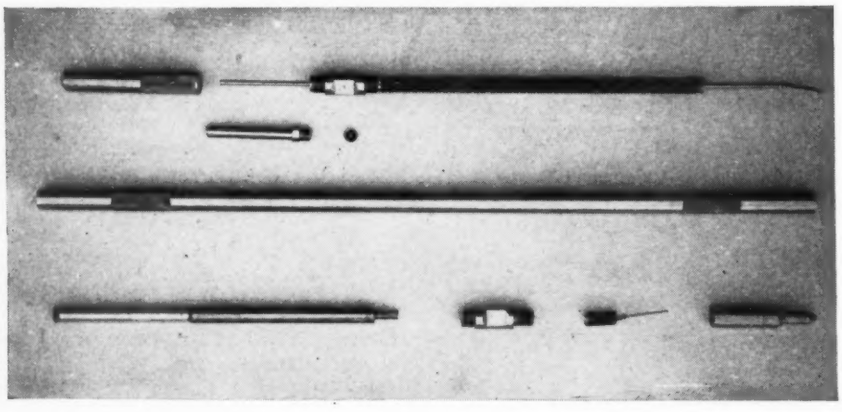
The stylus marker is of brass or steel depending on the chart used. The marker is preferably shaped to a chisel edge to prevent tearing and gouging of the chart. Spring tension in the stylus should be just enough to give a sharp, distinct recording. The chart used is a metallic sensitized paper with dimensions of 6.25 in. by 2.30 in. Charts are also available in thin sheets of etched copper or copper having a white enamel coating on one side. Although less expensive, the sensitized paper is adversely affected by moisture. This is a minor point if the instrument is maintained in good condition. The charts are carefully cut to size so that they exactly fit the inside of the drum. This minimizes slipping and reduces the tendency of the stylus to hang on the edges of the chart, thus insuring a smooth surface on which to record.

Chart carriers are rotated by a thermal motor or clock. The motivating element and chart drum comprise a unit.

The thermal motor consists essentially of a bimetallic helix, one end of which is connected to the carrier case and the other end to the drumshaft. A change in temperature causes differential expansion of the metal strips of the helix and thereby rotates the shaft. For each degree rise in temperature the motor turns approximately 2½ deg. The position of the motor in the instrument shows that heat transfer from the well bore must take place through four mediums before reaching the helical spring. In making the survey, this insulation insures an appreciable heat lag and thus enables the motor to continue turning sufficiently to inscribe a well-defined lateral line each time the instrument is brought to rest. The thermal motor, therefore, is used in surveys where a temperature gradient can be utilized to actuate the motor. This means making a continuous traverse of a well from the surface to the bottom stop in the survey. Under optimum conditions, a survey consisting of eight stops may be made and still have all points legible. In general, only five or six stops may be necessary to define fully the pressure traverse. The operator must exercise judgment regarding the time to be allowed at each stop, according to the rate of descent, status of well, stop program, and anticipated temperatures.

The clock is used to advantage when it is necessary to make a large number

Fig. 2. Component parts of Standard Depth Pressure Recorder



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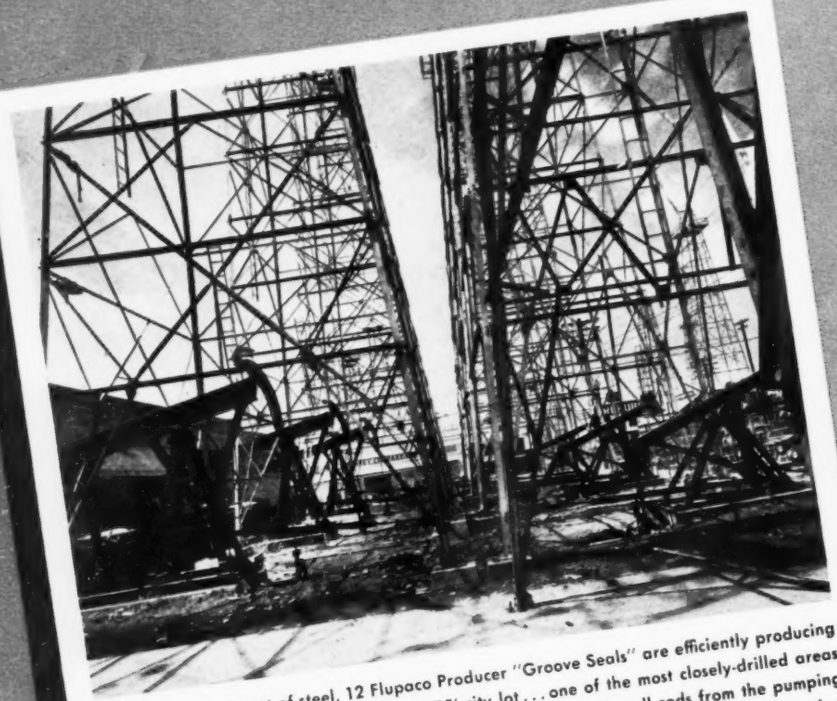
M11-5

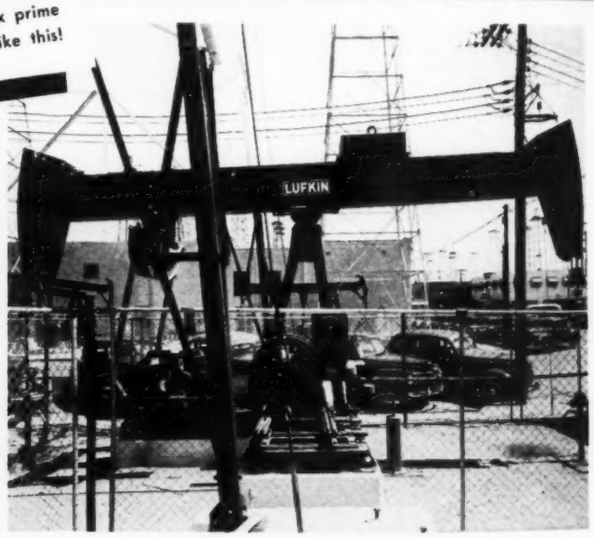
UNUSUAL WELL HOOK-UPS SHOW FLUPACO PUMP ADAPTABILITY



1 Under this forest of steel, 12 Flupaco Producer "Groove Seals" are efficiently producing oil from 12 wells located on a 25' x 75' city lot . . . one of the most closely-drilled areas in the world! Note, in this partial view, the set-up in which pull rods from the pumping units at left run the pumping jacks at right—pumping twelve 3,600' wells from six prime movers. You can't use pumps that bind, wobble or break easily on a hook-up like this!

IT'S one thing for a pump to meet the ordinary production jobs with adequate performance. *But it's a different story when well hook-ups become complicated.* **Then, more than at any other time, dependable pump performance is a vital factor in the smooth, successful and *low cost* operation of the entire production program!**

Every oil man who has production problems will be interested in the illustrations on this page. These three production hook-ups won't be found in the ordinary field. *They are three out of scores of out-of-the-ordinary installations that thoroughly prove Flupaco Pump adaptability to ALL types of production problems . . . to ALL pumping jobs, easy or tough!*



2 Here's an unusual surface hook-up in which *two* separate wells are pumped with *one* beam. Nearly perfect balance is, of course, required for this operation . . . and because Flupaco Pumps are free-falling and give little or no plunger drag, two "Marginal" Fluid Packed Pumps were chosen to complete this unique and well-engineered hook-up.

3 Another "twin well" hook-up, with two beams driven from a single gear box. These particular wells are on intermittent production, making free-starting pumps doubly important. The Flupaco Producer "Groove Seals" in these wells are ready to go whenever required, and complete the ingenuity shown in making all necessary equipment fit the cramped space allotted in this closely-drilled city lease.

NO MATTER WHAT YOUR REQUIREMENTS, Flupaco Pumps will lift more oil longer—for less. Whether your production needs call for the *usual* or *unusual* in hook-ups, Fluid Packed's new Catalog No. 9 will give you full information on the correct Flupaco Pump for your wells. Send for your free copy of this valuable catalog *today*—or contact your nearest Fluid Packed representative!

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of stops, when the stops are close together, or to obtain a time-pressure relationship. In a time-pressure survey the bomb is usually suspended at one point for the entire period. Clocks are available with running times to 72 hr. and with various rates of rotation.

The chart carrier seats on a shoulder on the inside of the shell and is held firmly in place by a spring in compression at the upper end of the carrier. A frequent check of the chart drumshaft is made for alignment and end play. Misalignment will cause a wavy line to be drawn on the chart as it is rotated. End play in the chart carrier shaft may introduce an error equivalent to the amount of play. A loose drumshaft will cause a wide trace on the chart.

The inside of the shell should be kept clean and polished to minimize friction.

A maximum recording thermometer is inserted in the top of the sinker bar. If desired, the thermometer well itself may be filled with mercury to obtain a quicker transfer of heat to the thermometer. It has been found quite satisfactory, however, to dispense with the mercury by allowing a slightly longer stop on bottom. A cushioning medium is provided around the armored thermometer case to reduce breakage. Discarded C-cups have proved very satisfactory for this purpose.

A rope socket at the upper end of the assembled instrument provides a means of coupling to the sounding line. The free end of the wire is tied around a metal spool, which is carried in the rope socket, and a number of turns taken around the wire itself. The inside width of the spool is slightly less than the three turns of wire wound around it. This is quite important, as the friction hold prevents the wire from slipping. Tests made to determine the strength of this tie showed that failure occurred slightly below the minimum tensile strength of the wire. A new tie is made for each run. The outer surface of the socket is grooved and beveled; the grooves facilitate fishing for the instrument if lost in the hole, and the bevel minimizes any tendency of the instrument to hang up when being pulled through a restriction or past square shoulders.

The line currently in use consists of 12,000 ft. of 0.066-in. sounding wire having a minimum tensile strength of 230,000 lb. per sq. in. and a minimum torsion of 27½ per 100 diameters. As a precaution, the line is replaced every two months. It is estimated that on the average, 1,500,000 ft. of hole will have been surveyed with one line.

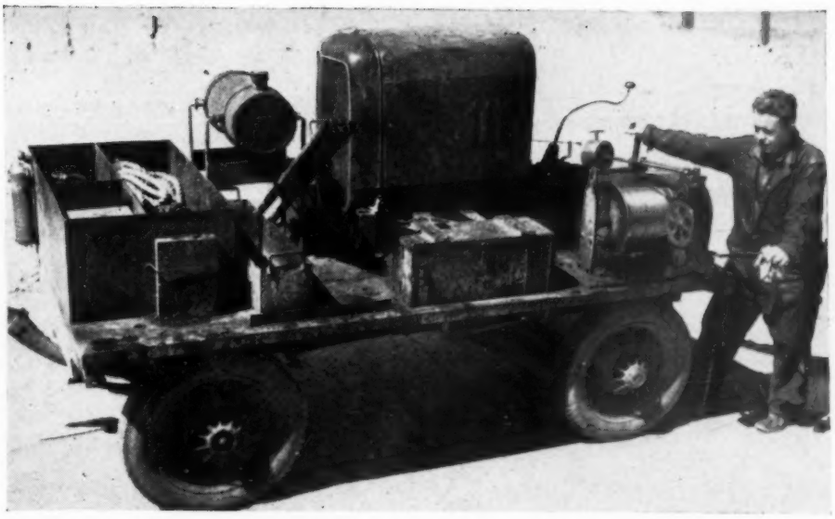


Fig. 3. Shop-made trailer hoist

Calibration

Before placing a new spring or pressure element in operation, it is carefully calibrated. During the life of an element it has been found that its characteristics will change sufficiently to require recalibration at frequent intervals, particularly in the first month or two of use. The frequency will depend on the accuracy desired. If a damaged element has been repaired or replaced, a recalibration of the spring is necessary. In addition to the examination of the spring as already outlined, it is checked for initial tension. No movement of the spring can take place unless pressure is applied to the plunger in excess of the initial tension.

Hysteresis is present in the spring and is largely due to friction. This is evidenced by a lag in spring movement; so if the instrument is to be used for recording decreasing pressures, another calibration curve is required.

The equipment used in calibration consists of a deadweight tester, and a 4-in. chamber filled with oil of high flash point for the temperature bath. To maintain the bath at constant temperature, a thermostat can be used to advantage together with some means of circulating the oil to insure uniform temperature distribution. If automatic control of temperatures is not employed, care should be exercised in bringing the instrument to the correct temperature. A reasonable length of time should be allowed for the instrument to assume the temperature of the bath.

In preparation for calibration, the instrument is assembled without the sinker bar. A ¼-in. copper line filled with oil leading from the deadweight tester is connected to the inlet port of the footpiece. Following a pressure test of the connections, the instrument is placed in the bath in an upright position. A sufficient number of charts are marked with a zero line at atmospheric temperature to eliminate the possibility of introducing the slight error that might result if drawn at elevated temperatures. Atmospheric temperature is chosen as a reference, as it is assumed that the instrument is approximately at that temperature when the zero line is drawn for the routine pressure survey.

The spring is calibrated at four temperatures; that is, room temperature and three elevated temperatures so chosen that they will adequately cover the range of subsurface temperatures to be found in the field surveys. With the instrument set up and by means of pressure application, the operator deflects the spring to full extension for several cycles; in this manner the moving parts are effectively lubricated. This "exercising" is repeated for each temperature series. In using a deadweight tester, it is vitally important that each pressure increment be applied slowly so that the balance pressure is not exceeded. At this time the chart carrier is manually rotated through a short arc to inscribe a lateral line on the chart. During calibration of the spring the instrument is rattled against the sides of the bath in simulation of the jarring that the instrument is subjected to in field use. The jarring effectively decreases the friction and the intensity of jar is governed by direct comparison with that noted on charts from actual surveys. The remaining friction may be disregarded as its effect on pressure readings becomes a part of the calibration curve.

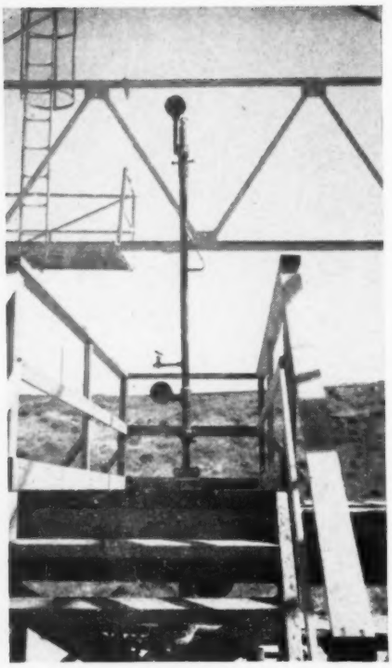


Fig. 4. Lubricator for pressure instrument

Field Equipment

The field equipment used in running the depth pressure instrument consists of a wire-line hoist equipped with an odometer and a lubricator.

The shop-built trailer hoist shown in Fig. 3 was designed for economy, practicability, and flexibility. Power is supplied by a four-cylinder internal-combustion engine, the supports of which are welded to a plate resting on the bed of the trailer. The engine is coupled to the hoist drum by means of a belt drive, which provides a speed reduction from motor to hoist of about 3.8 to 1, giving suitable line speeds and a torque that does not exceed the strength of the sounding line. Operation of the motor is quite simple as it has the standard automotive shift and self-starter.

An inclined tubular rack on the bed of the trailer accommodates the various springs, chart carrier, and instrument parts for safe transportation. A small tool box provides for the smaller wrenches, extra stylus, packing, etc. A larger steel box has ample space for large hand tools and rigging-up gear. Steel brackets on one side of the trailer are provided for the lubricator.

The lubricator, shown in Fig. 4, has a flange at its base and just above it a coupling of the single bolt type. Thus the lubricator may be quickly adapted to whichever type of fitting is found on top of the Christmas tree. Both sheaves shown are free to swivel or rotate around the lubricator. The lower sheave was added for convenience and safety. A bleeder is also provided.

When the derrick has been completely dismantled, a platform or a steel "A" frame must be provided for rigging-up. There is, however, a lubricator in use at this time that does not require either installation. This lubricator is equipped with a hinged base, which, when bolted to the top of the Christmas tree, enables the operator to push the lubricator into place by means of a length of pipe or stiff rod. A convenient frame is shown in Fig. 5 of such height that a large lubricator and a comparatively long string of tools can be accommodated.

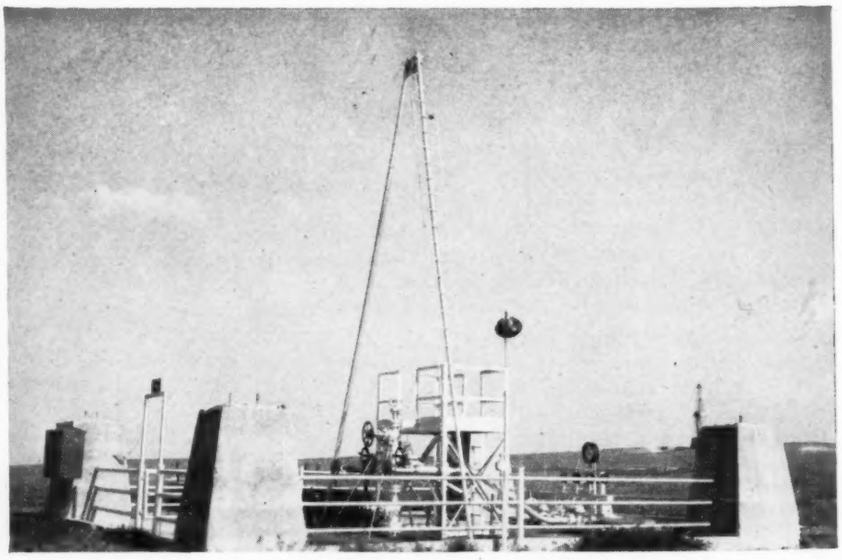
Field Procedure and Practices

To make the pressure survey, the operator is supplied with a run ticket containing the following information: (1) well number, (2) total depth, (3) plugged or bridged depth, (4) last pickup depth obtained with the instrument, (5) liner top, (6) casing shoe, (7) tubing depth, (8) tubing crossover, (9) seats in tubing, (10) obstructions in tubing or casing, (11) spring to be used, (12) stop program, and (13) notation of any difficulty encountered on previous runs.

Upon reaching the well the crew first verifies the status of the well. If the well is flowing it is checked for tubing or casing flow. If the flow is very unsteady or the status has been changed recently a more favorable time will be chosen for the run if possible. Oil gauges are taken before and after completing the run as a check against oil production measurements made over a longer period and to determine whether or not the survey has been made under conditions of steady flow in the well.

Before each run the footpiece is carefully filled with castor oil and a screw plug inserted in the inlet port to prevent undue loss of the oil during assembling and rigging-up operations. All pressure joints are oiled. A zero line is drawn on the chart at time of assembling. After making the sounding-line tie and with the instrument completely assembled, it is pulled into the lubricator. At this time the small screw is removed from the inlet port of the footpiece. The lubricator and instrument together are then hoisted into place and the lubricator coupled to the top of the Christmas tree. Wellhead pressure is admitted slowly to the lubricator to prevent the instrument spring from receiving an impact, which might cause overtravel. Using test gauges, the tubing and casing pressures are then read and recorded. Later, a check may be made against the lubricator pressure as registered on the chart and inaccuracies in spring operation noted. The instrument is then run into the well. As each predetermined depth is reached, the descent of the bomb is slowly checked so that the inertia of the spring does not cause stylus overtravel. At each stop sufficient time is allowed for a lateral line to be drawn on the chart as the drum rotates. Speed of descent is important. Consistent use of one speed will give comparable results inasmuch as the instrument will always be subjected to the same degree of jarring. According to tests made, a speed of 800 ft. per min. is considered as the optimum for descent.[3] Pulling-out is continuous except when entering the tubing or any restriction. As a matter of precaution

Fig. 5. Frame for rigging-up



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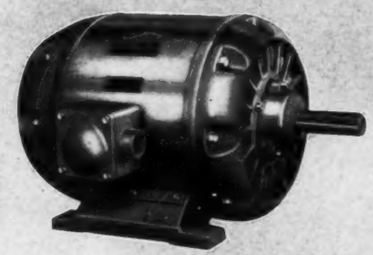

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in pulling out, hand contact is used for a distance of 40 ft. below and above each restriction.

In "bombing" a deep well it will be found that there is considerable stretch in the line, and as a result there may be some uncertainty that the instrument has been pulled into the lubricator. By shaking the lubricator the presence of the instrument will be noted by the resulting rattle. Such a precaution may prevent the loss of an instrument due to inadvertently closing a valve or gate on the sounding line.

Except when otherwise instructed, the operator obtains a "pickup" depth as a matter of routine. A record of the rate of sanding-up is therefore available.

If a small leak develops at the C-cup, it may not be noticed until the instrument is disassembled. Even though frequent spring changes are not required while making the field surveys, it is customary to disassemble the instrument solely for the purpose of checking this point.

A general policy is followed in planning the stop programs for the surveys. For a static survey, several stops are made to define the gas gradient and also sufficient stops in the fluid (liquid) column to determine the fluid (liquid) level under the existing surface pressures and the oil-water interface if one exists. A stop is also made at some datum plane as a matter of convenience in subsequent utilization of the data.

When the well is flowing through the tubing several stops are made in the tubing and one at the tubing shoe, one at the top of the top perforated interval, and one at the base of each set of perforations. In this manner, significant breaks in the flow gradient may be noted. If the well is flowing through the casing, only two or three stops are made inside the tubing and one just above the tubing shoe. Ordinarily, the recorder is not run below the tubing if the flow is from the annulus. No difficulty would be experienced in going out of the tubing but there might be trouble in trying to reenter the tubing. On occasions, pressure "runs" in a flowing well may change the flow characteristics and cause an appreciable change in the rate of flow.

In making time-pressure runs of wells produced by intermittent gas-lift, the procedure is to run the bomb immediately after the well has made a slug of oil so as to avoid meeting a strong upward flow of oil and gas. The bomb is lowered rapidly to the point where it is to be suspended. A strong flow might drive the instrument up the hole and possibly kink the line.

Many problems may arise in the operation of the subsurface pressure recorder that cannot be anticipated. Many of them will not be fully appreciated until they have been encountered in the course of operations. Their solution is therefore dependent on a thorough knowledge of the equipment.

The writer wishes to express his appreciation to the management of the Kettleman North Dome Association for permission to publish the information contained in this article.

——☆☆☆——

P 622.2
P 615.22

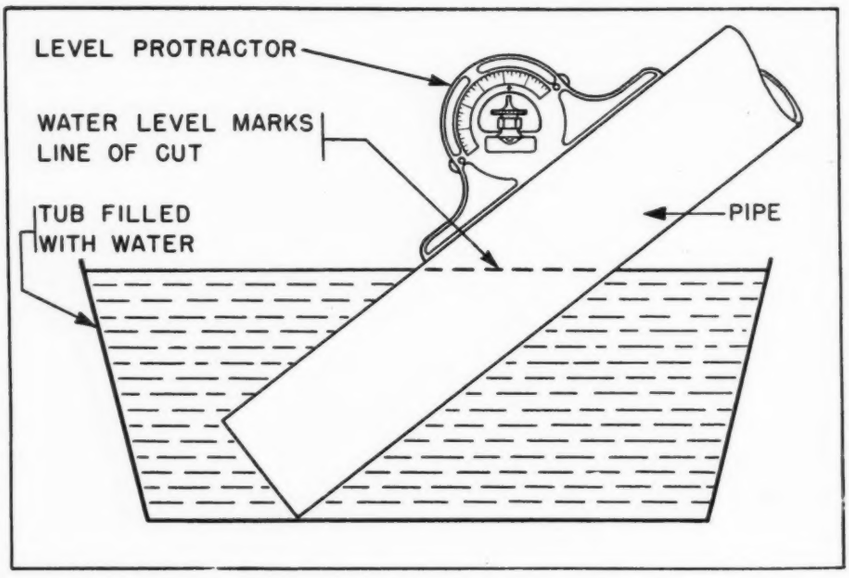
Simple Way to Make Mitered Pipe Joints

THERE is a remarkably easy way to mark the correct line of cut on pipe when making mitered joints for pipe elbows. Sole requirements are a tub of water and a level protractor.

Submerge the end of the pipe in water at one-half the desired angle of bend, using a level protractor. By marking the pipe at the water level with chalk or soapstone, the correct line of cut for that particular angle is readily indicated. If desired, a templet can be made for duplicating the cut on other pipe of the same diameter, by placing a piece of heavy paper squarely about the pipe, tracing the cut, and then cutting away the scrap portion of the paper to form a permanent templet.

In the example shown in the sketch, the pipe is inserted in the water at an angle of 37½ deg., which will give a two-piece mitered joint of 75 deg. If a bend consisting of more than two sections is desired, the correct angle of each cut required to arrive at the total angle of bend can be determined from the following equation:

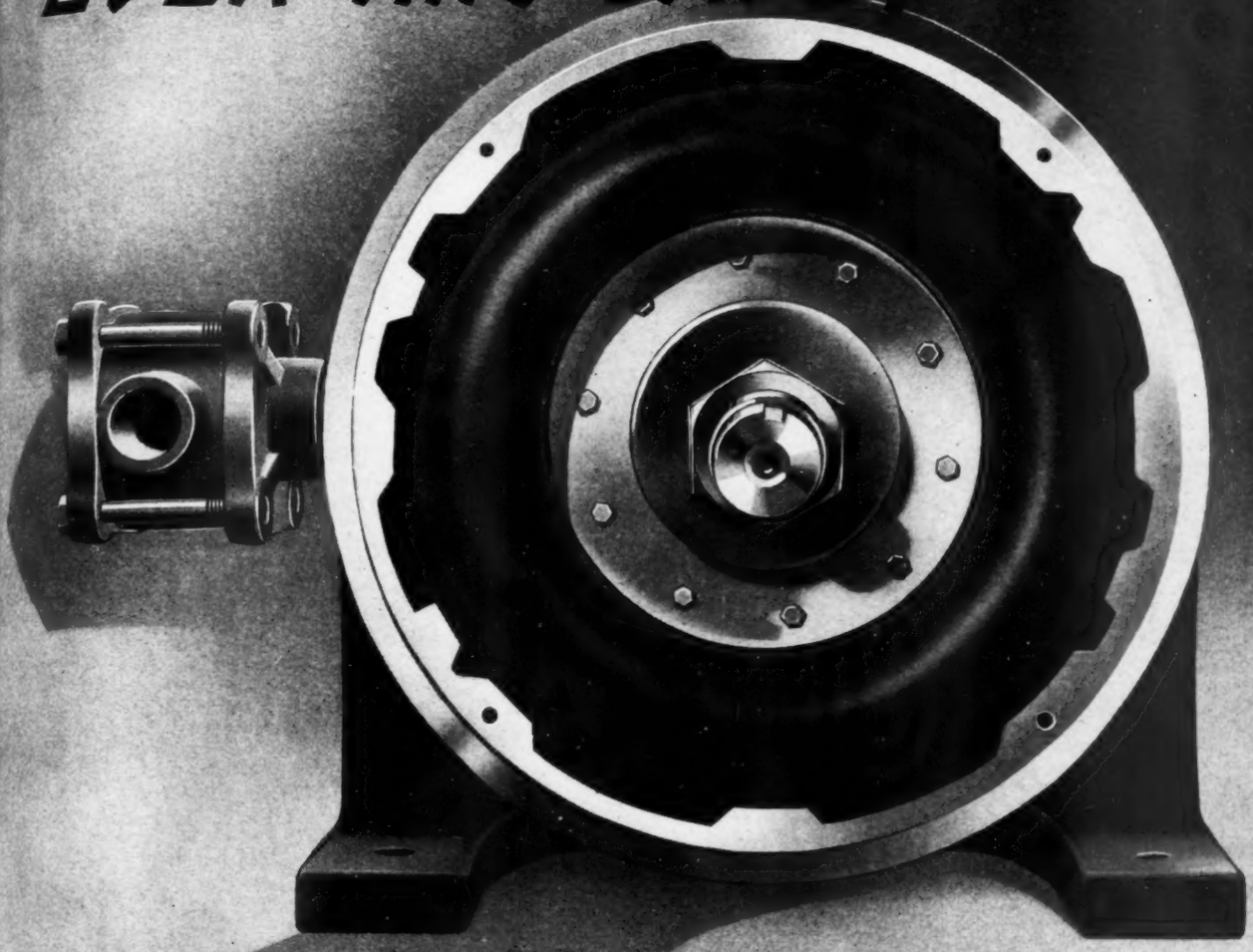
$$\frac{\text{Total angle of bend}}{2 \times (\text{number of sections}-1)} = \text{angle of cut.}$$



Sketch indicating the simple method of making the line of cut on the pipe

For the information contained in this item, and the sketch, acknowledgment is made to The Linde Air Products Company, New York, New York.

EVEN AIR GAPS!



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P 721.3

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Cracked Gasolines

Synopsis of Preceding Meetings

The first discussion involved a review of the various hydrocarbons and their thermodynamic qualities as related to the cracking of petroleum and its products. The main hydrocarbons in petroleum and its cracking products are paraffins, olefins, naphthenes, and aromatics. Of these, olefins are virtually non-existent in most crude oils.

Points covered in the discussion included the following: (1) chemical stability of compounds; (2) relative crackability of hydrocarbons; (3) energies released or absorbed in cracking; (4) the decomposition reactions, and (5) effect of pressure on reactions.

In discussing the development of cracking, it was pointed out that the ability of petroleum to crack was discovered by the accidental overheating of a topping shell still, resulting in an unexpected straw-colored distillate, which was in reality cracked distillate.

The importance of clean recycle was first recognized when operators of earlier units discovered that clean stocks permitted longer runs with correspondingly small percentages of gas and coke formed.

Additional gasoline will be obtained if a multiple coil heater is used so that more rigid control from the fractionator will permit separate cracking from the various cuts at optimum conditions. Quenching will be essential to correct control of the time and temperature element.

The excessive heat brought to the fractionator from the reaction chamber can be disposed of in a number of ways: (1) the charge may be used as a quench; (2) heat can be exchanged with the charge to any adjacent unit; (3) the remaining heat must be removed by reflux in the usual way.

The charging stock is less refractory than recycle stock. A cut cracked above its optimum temperature will produce excessive amounts of gas and coke. For maximum gasoline, therefore, it is necessary to separate both the charge and the recycle stock into small cuts. This would necessitate the separate treatment of charge and recycle. These cuts would then be treated at the temperature at which minimum gas is formed and quenched immediately to keep down the formation of polymers and condensation products that reverse the process of cracking and go to form coke. All this procedure would mean many cuts and high recycle ratio. Of course, for practical purposes the above method would have to be modified in order that investment in equipment would be within reason.

When making 70-octane gasoline instead of striving for maximum gasoline yield, a multicoil unit would be used but high reflux ratios would not be feasible for a commercial unit. Ratios from 3 or 5 to 1 were suggested; this would crack the stock deep enough to obtain the desired results. This deeper crack would of course produce a greater percentage of gas and coke, along with many more olefins and aromatics. These compounds tend to make the gasoline more unstable and must be handled accordingly. The conclusion reached was that if modern methods are used the yield of 70-octane gasoline would not be more than 5 to 10 percent less than the maximum yield obtainable.

Definitions concerned with cracking were defined in the following terms: polymerization is the joining of molecules of the same families; condensation is the combination of unlike molecules in a carbon-to-carbon bond with the elimination of hydrogen or water. These two terms come up frequently in the discussion of the chemical processing of petroleum and its products, sometimes in different shades of meaning.

Class Meeting No. 9

(Continued)

NOTE: Throughout the class proceedings, no attempt is made to distinguish the identity of the pupil speaking. When a series of remarks are made by pupils, it usually denotes an interchange of discussion among the class members themselves.

Leader: We have talked about acid heat test and the significance of it. Does anyone wish to add any comments on that? We have talked about the Houdry process and mentioned that they added a blend of alkylates to the Houdry gasoline. What is the significance of this practice relative to the acid heat test?

Pupil: According to an article on the Houdry process the distillate is very good for aviation gasoline because it has a low acid heat and it was stated that the Army required low acid heat. Evidently reaction is better with saturates than unsaturates.

Leader: If you don't mind being referred to another table, we shall turn to page 303 (Table 6). These tables are full of meaning. There is a Houdry cataytic gasoline that shows an acid heat of 60 to 120. Although the Army discontinued the acid heat test, they have been insisting on 200. I do know their practice of blending the alkylates in; therefore, you can see it would be necessary, if this 60 to 120 is correct. The Army has thrown the acid heat test out, and I believe the reason is the pressure of demand—if the supply and demand do not balance, one or the other has to give. What significance does this have?

Pupil: According to this test, it is more of a measure of olefins than aromatics, because sulphuric acid works much faster on the olefins than the aromatics. Aromatics act to a slower degree.

Leader: All right, we must believe that the large yield of unsaturates is detrimental to performance. There is another interesting subject, and that is gum.

Pupil: That is the reason they don't like unsaturates—the gum formation in the lines.

Leader: I think that is right.

Pupil: I should think a saturated fuel would be better.

Leader: How is gum formed?

Pupil: By oxidation. It comes from olefins.

Leader: Yes. It is formed from the oxidation of unsaturated compounds, and what does that produce in the gasoline?

Pupil: Gum.

Leader: There is a step ahead of that. Peroxides, I should say, are formed first. Those are bad actors, because they are soluble in gasoline and they in turn react and produce still more gum and it goes on and on.

Pupil: That brings back sad memories—I don't want to even hear about it.

Leader: Yes, you and I had a job attempting to make aviation gasoline out of pressure still products, didn't we?

In that instance, we didn't supply the product to the Army, but we had a rather high acid treatment and then took the low boiling-point fractions and got them treated promptly, and finally made an aviation gasoline. About this dissolved gum—does the copper dish gives us a correct measurement of dissolved gum?

Pupil: No, it hasn't broken down into gum yet. It is in the peroxide stage.

Leader: Do you think the copper might enter as a catalyst?

Pupil: I don't know.

Leader: It probably does. What develops next? Is that the beginning of the last stage?

Pupil: The pre-form test is next.

Teacher: Yes, that indicates gum already existent in the gasoline. What does the copper dish test tell you?

Pupil: It is an indication of storage oxidation. We used to call it potential gum.

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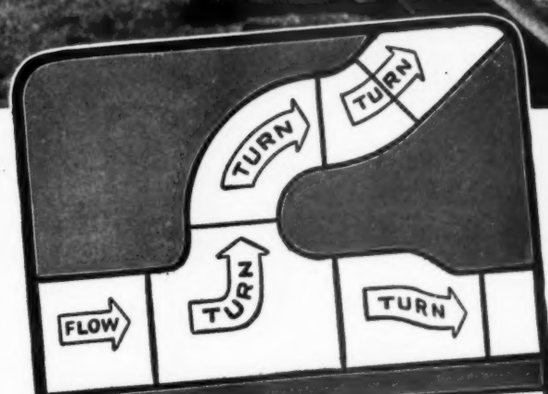

As indicated in the drawing above, there are vital "turns" in piping other than at elbows and returns. Tees, reducers, laterals, and nipples likewise entail abrupt changes in flow direction that result in *added* strain, friction and wear at these connections. The built-in strength of *all* Tube-Turn welding fittings gives unequalled reinforcement for *each* of these *danger spots.*

TABLE 6

Average specific gravities, aniline points, iodine numbers, and acid heats of cracked gasolines (untreated)

Cracked gasoline	Specific gravity at 15°C.	Aniline point (°C.)	Iodine number	Acid heat (°F.)
Mixed-phase, from Pennsylvania or Mid-Continent crude	0.730	40	100	120
Mixed-phase, from naphthenic crude	0.750	30	100	120
Vapor-phase	0.770	10	200	200
Hydrogenation, moderate-temperature	0.720	50	5	5
Hydrogenation, high-temperature	0.800	—10	5	5
Catalytic, Houdry	0.730	30	50–100	60–120
Catalytic polymerization of gases	0.735	30	150	
Thermal conversion of gases	0.720	40	100	

This table appeared as Table 135 on p. 303 of *Conversion of Petroleum* by Sachanen.

Leader: How much are we going to say is allowable?

Pupil: Possibly 20 mg. to 100 cc. I have seen samples in quart bottles that were several years old and practically all of them had turned to gum. Gum formation is said to be a logarithmic function of time, so you can see it would multiply pretty fast. I doubt whether time is the only factor.

Leader: How much gum is determinable by pre-form?

Pupil: 10 mg.

Leader: That is in 100 cc. of gasoline. So that is the gum already in it. Something better than the copper dish test is this induction period. Will someone describe that?

Pupil: The test is performed by measuring 100 cc. of gasoline into a glass bottle, about a 4-oz. bottle, and inserting this into a bomb of oxygen. The test is conducted at 100°C. and shows on a chart the number of hours that the gasoline will stand before the pressure of the oxygen drops about 5 lb.

Leader: As the gasoline uses the oxygen, the test will be a measure of the ability of the gasoline in storage to absorb air and over a period of time. What can you do to lengthen the time if the test indicates 2 hours, for instance?

Pupil: You can use an inhibitor.

Leader: What does that do? Does the inhibitor combine with the oxygen? If you were walking along and a lion was nearby, you might stick a bone in his mouth and try this as an inhibitor so he would not bother you, for a little while at least.

Pupil: If you add the inhibitor, it doesn't cause the pressure to drop. The amount of inhibitor compared with the amount of the gasoline is immaterial.

Pupil: Sachanen makes the statement that the content of potential gum has no influence on gum formation in engines.

Leader: I agree with him. I am of the opinion that if you can get the gasoline to the engine before your potential gum has formed it will be consumed without difficulty. It is only the gum actually in the gasoline before it reaches the user that is detrimental. There is a table on page 304 (Table 7) that shows the rate of the gum formation in storage. You will note it took more than 120 days before the gum content became serious. Will someone give me the value of this copper dish?

Pupil: Make it about 30 to 50.

Leader: Universal Oil Products Co. has made quite a study of this and always recommends 25 as being a safe maximum.

One other thing we did not bring out is that five hours is equivalent to a time period of one year; so you had better get rid of your gasoline within a year. On one occasion a small tank of gasoline was set aside for the research laboratory and tests were run periodically for more than a year. It was still good gasoline at the end of a year and it had a value of about 6 hours when it was stored, so that would reaffirm that statement roughly.

Pupil: If you had a tank of gasoline you had to keep for a long period of time and the gum content got high, what would you do to it?

Leader: You would re-distill it. I think that would be cheaper.

Pupil: Is there any gum in a saturated gasoline, that is, top gasoline?

Leader: I think not.

Leader: I have seen some gasoline stand in containers for 10 years and there was not a trace of gum.

Pupil: Was this gasoline inhibited?

Leader: Yes, but there was no acid treatment. Here are some comparative data:

	Pre-formed	Copper Dish
Light	1	325
Heavy	40	15

Here is a light cracked gasoline that had a glass dish gum of about 1 milligram and the copper dish 325. A heavy cracked gasoline made from the same material by some of the aviation gasoline manufacturers you will recall had pre-formed gum of something like 40 and a copper dish value of 15, so you see the influence of the type of hydrocarbons. If somebody will read me the table on page 325 (Table 8), I want to emphasize the two types of crudes. Pennsylvania, Oklahoma City, and East Texas are representative of the paraffinic in general. What are the octane numbers of straight-run and cracked gasoline?

Pupil: 42 and 65 are the octane numbers. About 48 would be the average.

Leader: What would you call the number of the cracked gasoline?

Pupil: About 67 would be the average number.

Leader: Comparing these, therefore, we have:

	Straight-run	Cracked
Paraffinic	48	67
Naphthenic	68	74

If you had your choice, you most certainly would strive to get naphthenic crude. You can understand some of the superiority the Gulf Coast has had economically over the Mid-Continent.

Pupil: Yes, but the Mid-Continent has something that offsets that.

Leader: What is that?

Pupil: The lubricating oils.

Leader: Yes, the Mid-Continent has superiority there.

Pupil: Is the octane number the only thing you want to refer to?

Leader: I was just thinking of the octane number at this moment. Are there some other points we should mention?

Pupil: How about odor? Hasn't sulphur most to do with that?

Leader: Yes.

Pupil: Doesn't sulphur decrease octane number? You can eliminate sulphur but not paraffins. Odor is the result of sulphur.

Pupil: Is 67-octane cracked gasoline more lead sensitive than naphthenes for cracked crude?

Leader: I think it is.

Leader: Now, then, what is the effect of cracking residual fuel compared

TABLE 7

Gum formation in storage

Time of storage (days)	Dissolved gum (mg. per 100 cc.)	Rate of gum formation per 2 months
0	0	
60	1	1
120	3	2
180	26	23
240	64	38
300	101	37

This table appeared as Table 136 on p. 304 in *Conversion of Petroleum* by Sachanen.

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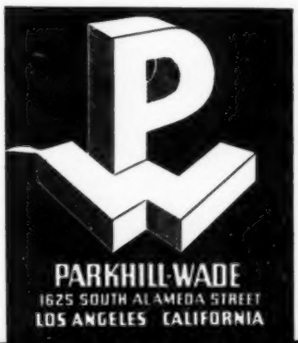

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TABLE 8

Octane numbers of straight-run and cracked gasolines untreated from the same crudes (C.F.R. Motor Method)

Crude	A.P.I. octane number of straight-run gasoline (400°F.)	Octane number of mixed-phase-cracked gasoline (400°F.)
Pennsylvania, Michigan	42	65
Oklahoma City	48	68
East Texas	54	68
West Texas, Winkler	60	71
Gulf Coast, Mixed	66	74
California, Huntington Beach	57	70
California, Midway	68	74
Illinois	54	67
Arkansas, Smackover	68	73
Venezuela, Cumarebo	52	63
Venezuela, La Rosa	58	70
Mexico, Poza Rica	44	65
Russia, Grozny	42	64
Russia, Baku-Surachany	60	66
Iran	52	69
Iraq	45	67

This table appeared as Table 148 on p. 325 in *Conversion of Petroleum* by Sachanen.

with gas oil? If you were making residual fuel from Oklahoma City crude and gas oil from Oklahoma City crude, and then cracking to optimum conditions for both of them, would you anticipate much difficulty?

Pupil: A very slight difference. I think the difference would become unimportant. It might be slightly in favor of gas oil. I think that the result from your light stream would be fully the equivalent of the gas oil, but the heavier stream would not be the equivalent.

Leader: So that we might say the principal difference would lie in the nature of the hydrocarbons in the charging stocks. We can alter this octane by the various types of cracking:

	Octane No.
Mixed phase cracking	66
Reformed thermally	69
Reformed catalytically	77
Vapor phase to high temperature	85 to 90
Cracking catalytically	78
Polymerization—catalytic	81
Alkylation—catalytic	88

Here we have aromatics (pointing to vapor phase) and here we have saturates (pointing to alkylation), and if you wanted to build up high octane number with lead, which would you use?

Pupil: You would use the alkylation.

Leader: On the other hand, if you would use that, in a tank of motor fuel, you might use whichever process fitted the economics or source of raw material. Does alkylation presuppose you will have a source of low molecular-weight hydrocarbons?

Pupil: Yes.

Leader: It is rather interesting to note that one area has adopted mixed-phase cracking, catalytic reforming, and catalytic polymerization.

Pupil: Which should we adopt?

Leader: Possibly our choice should be along the same lines.

Pupil: I was curious to learn how aviation gasoline differs from motor gasoline with respect to vapor pressures and distillation range?

Leader: Possibly I can answer that. Let's say we are talking about motor gasoline first. Consider the 10 percent point and assume it is summer. These are actual specifications:

	Motor	Airplane	Octane
10%—loss added	140	158	73-80-87
50%—loss added	235	212	90-95
90%—loss added	340	257	
Endpoint	400	311	
Reid vapor pressure, lb. per sq. in.	8.0	7.0	

Now you see you begin immediately to widen out on the motor gasoline. You have a flatter curve on the aviation. Why would the Reid vapor pressure be lower?

Pupil: If you would go from 2,000 to 15,000 ft. altitude you would see a difference.

Leader: If you go to 10,000 ft. altitude, what happens to the boiling point?

Pupil: It would decrease.

Leader: I believe at the local airport you can buy 73 as one grade and one other that I believe is 87 A.S.T.M. octane. We are just about getting everybody out of the habit of talking Research Method. Most refiners are using the A.S.T.M.

Pupil: Generally when they sell it, though, they like to show their highest figure.

Leader: Yes, that is perfectly natural. There is another paragraph that shows these trends, on page 328:

	A.S.T.M. octane numbers		
	Mixed-phase cracked	Straight-run	Houdry
300 endpoint	74	58	78
437 endpoint	64	43	77

Here is a specific example of light and heavy gasoline. If we increase the endpoint to 437, the cracked gasoline drops to 64, and the straight-run to 43. Suppose we had run Houdry instead. Then we find we will have an octane number something like 78 at 300 endpoint and 77 at 437 endpoint. Not much drop, is there?

All right, if you had to produce a safety fuel of 300 initial and about 400 endpoint, doesn't it look as though this might be a source for some base material? What kind of flash do you think safety fuel would have?

Pupil: It would have a pretty high flash—about 100°.

Leader: I think it would be close to 100° closed cup. Obviously you can see that it would not be ignited so readily in case of a leak, and is safer all around. I think we would have heard more about safety fuel but for the fact that we have drifted into large quantity production of fuels.

Pupil: What is wrong with a high endpoint? There is more power.

Leader: From the standpoint of conservation of crude oils, there is no doubt that high endpoint gasoline is important. If high endpoints were mandatory, catalytic cracking probably would be even more important than it is now.

In the higher boiling point ranges, crank case dilution is the important problem.

Pupil: Why is that?

Leader: When the weather gets cold, the gasoline won't vaporize at the intake and it doesn't leave the crankcase oil so well. Let's continue. I should like to have the class discuss lead susceptibility of these hydrocarbons. Which are the poorest as a class? Are aromatics the best, worst, or average?

Pupil: I think they are the worst.

Pupil: What is the octane number of benzene?

Leader: About 90 to 100.

In the olefin group, some peculiar things occur. Do you recall that you had one group of olefins (the alpha type) and cyclo-paraffins that have very good lead susceptibility. The A-olefin is good, but there is this cyclic unsaturated group and actually they have about the poorest susceptibility. When you add lead to them the gasoline becomes lower in octane number. As a group, that is about what you would expect. Keep that in mind in planning for gasoline ten years from now.

Pupil: Your higher endpoint product would be more susceptible to lead,

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too, because of higher molecular weight.

Leader: Yes, that is correct. Although they are more sensitive, however, they are still lower in the scale so that you might be disappointed in the results.

Pupil: The ones with the best octane raw are the poorest with lead.

Leader: I want to give you something here that I referred to last week, and that is the effect of compression ratio on gasoline performance:

Compression ratio	*Gasoline performance*
5:1	— Same for all three fuels.
6.7:1	— Cracked gasoline had marked superiority at low speeds especially
7.85:1	— Straight-run was superior

There were three fuels used: vapor-phase cracked gasoline; reformed gasoline, and a 70-octane straight-run motor fuel. Those three fuels at a compression ratio of 5 to 1 acted somewhat the same. I mean they all gave about the same performance. When the compression ratio was increased to 6.7, cracked gasoline was superior. I think that is worth remembering, at low speeds especially. Low compression engines are not sensitive to the grade of gasoline. In the last few years, however, most cars are in 6:1 or 7:1 ranges, and cracked gasolines are showing a decided superiority. When you go to 7.85 to 1 compression ratio, straight-run is superior.

Pupil: Maybe that is why straight-run is preferred as aviation gasoline.

Leader: I think that is right. That trend has been noted by several investigators and no doubt we will hear more about it as time goes on. You may ask what does octane mean from the standpoint of road performance. I remember one investigator's work. He had a car tuned up to 70 octane and set the spark back to where it didn't knock and they put an 80-octane gasoline in it but did not change the spark on the car and got 7 percent better power. The following tabulation shows some interesting results:

Gasoline grade	*Performance*
73 octane	—Standard
80 octane	— 14 percent increase in power output
90 octane	— 38 percent increase in power output
100 octane	— 79 percent increase in power output
110 octane	—168 percent increase in power output

Even if these results should not prove to be exact, they point the way to some of the developments that are coming. Automotive engineers are just a little concerned at present about how they are going to design automotive engines in the future. To make use of 70 or 90 octane effectively, they are undecided on the economical way to do it. There are several high-compression engines now developed that will point the way and just as soon as fuels are available, they will appear on the market.

Class Meeting No. 10

Leader: The assignment tonight may duplicate in part some of the work we had last year when we discussed various light products of petroleum. With cracked gasolines, however, there are several problems that are worthy of special consideration. It is important, therefore, that we discuss *why* cracked gasoline is treated.

The object of treating cracked gasoline is to remove objectionable sulphide compounds or to change them into unobjectionable sulphur compounds. In the petroleum industry all sulphur compounds are expressed in percent of sulphur. A lengthy discussion probably could be made on what the allowable amount of sulphur should be, but it seems standards should be set up stating the allowable amount of the individual sulphur compounds. According to American and European authorities, however, the total percent sulphur should not exceed 0.1 percent (by the lamp method.) I was unable to find any discussions other than in the text[1] on the harmful effects of sulphur on automobile and airplane engines.

The sulphur compounds found in cracked gasoline are:

1. Free sulphur
2. Hydrogen sulphide
3. Mercaptans
4. Alkyl monosulphides
5. Alkyl disulphides
6. Thiophenes

Definitions of these compounds are as follows:

Sulphur (S): Active when heated. Moist sulphur is slowly oxidized in air to form sulphuric acid. Hot sulphur unites with carbon to form carbon disulphide.

Mercaptans (RSH): Mercaptans may be defined by comparing with sodium hydroxide (NaOH) where S is substituted for O and the hydrocarbon for Na. The hydrocarbon is usually signified by R.

Alkyl monosulphides (R-S-R): Similar to the mercaptains. Alkyl is the straight chain hydrocarbon attached to a monosulphide.

Alkyl disulphide (RSSR): The sulphur is more stable and therefore the compound is not so corrosive. These compounds do, however, decrease lead susceptibility.

Thiophenes (C_4H_4S): They can be partly removed by acid-treating and are ring compounds.

Two tests, the copper strip and the doctor test, are used to determine the allowable amount of sulphur in gasoline.

Compounds that react with copper strip are:

Sulphur
Hydrogen sulphide
Mercaptans

Those that do not react with the copper strip are:

Alkyl monosulphides
Alkyl disulphides (some)
Thiophenes

The copper strip is usually positive when free sulphur is 0.005 percent or more.

Compounds that react to doctor test are:

Hydrogen sulphide
Mercaptans

Mercaptan sulphur in a concentration of 0.001 percent is sour to gasoline.

Sulphur compounds are detrimental to gasoline because of the following disadvantages:

1. Bad odor
2. Corrosive properties
3. Discoloration in sunlight
4. Poor response to tetraethyl lead
5. Presence of sulphur compounds decreases octane number

Bad odor: Mercaptans and hydrogen sulphide in gasoline impart an unpleasant odor.

Corrosive properties: Corrosive acids are produced by oxidation of hydrogen sulphide in the presence of moisture. These acids are corrosive to both refining equipment and internal-combustion engines. Mercaptans are objectionable because they are highly corrosive. They also have objectionable odors.

Sulphur dioxide is noticed mostly in crankcases. At high temperatures sulphur dioxide is non-corrosive; but at the low temperatures found in the crankcase it is harmful.

The refiner's equipment that suffers most from corrosion by hydrogen sulphide are as follows:

1. Storage tanks
2. Gas lines
3. Pipe still tubes
4. Evaporators
5. Fractionator

Discoloration in sunlight: The chemical nature of the reactions of sulphur compounds in sunlight is not clearly understood, but it is believed such compounds as disulphides are oxidized, forming sulphuric acids. Free sulphur and disulphides produce a haze. Mercaptans give little effect.

EDITOR'S NOTE: Class Meeting No. 10 will be continued in a subsequent issue.

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[1] *Conversion of Petroleum*, by A. N. Sachanen. Published by Reinhold Publishing Company.

DI-HARD

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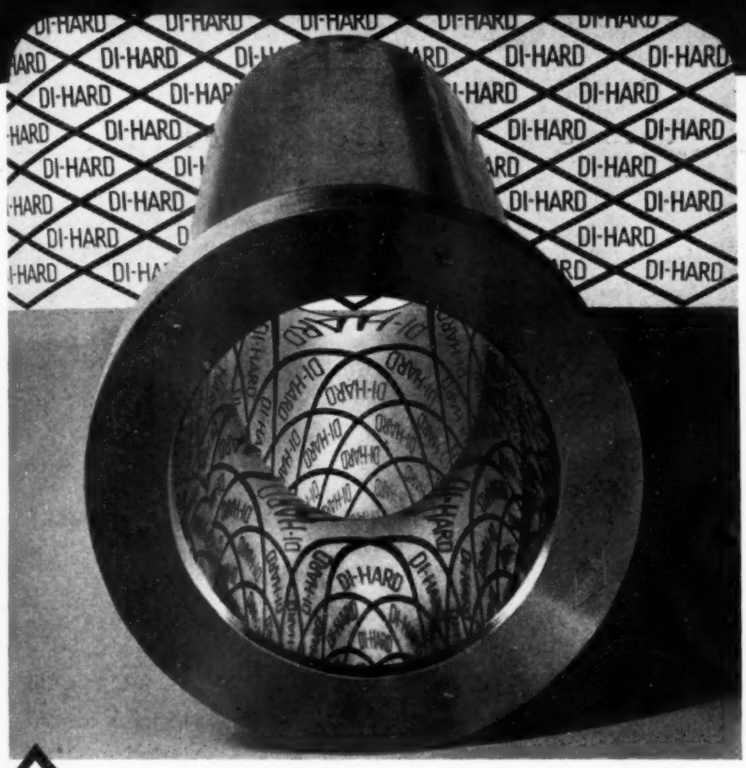

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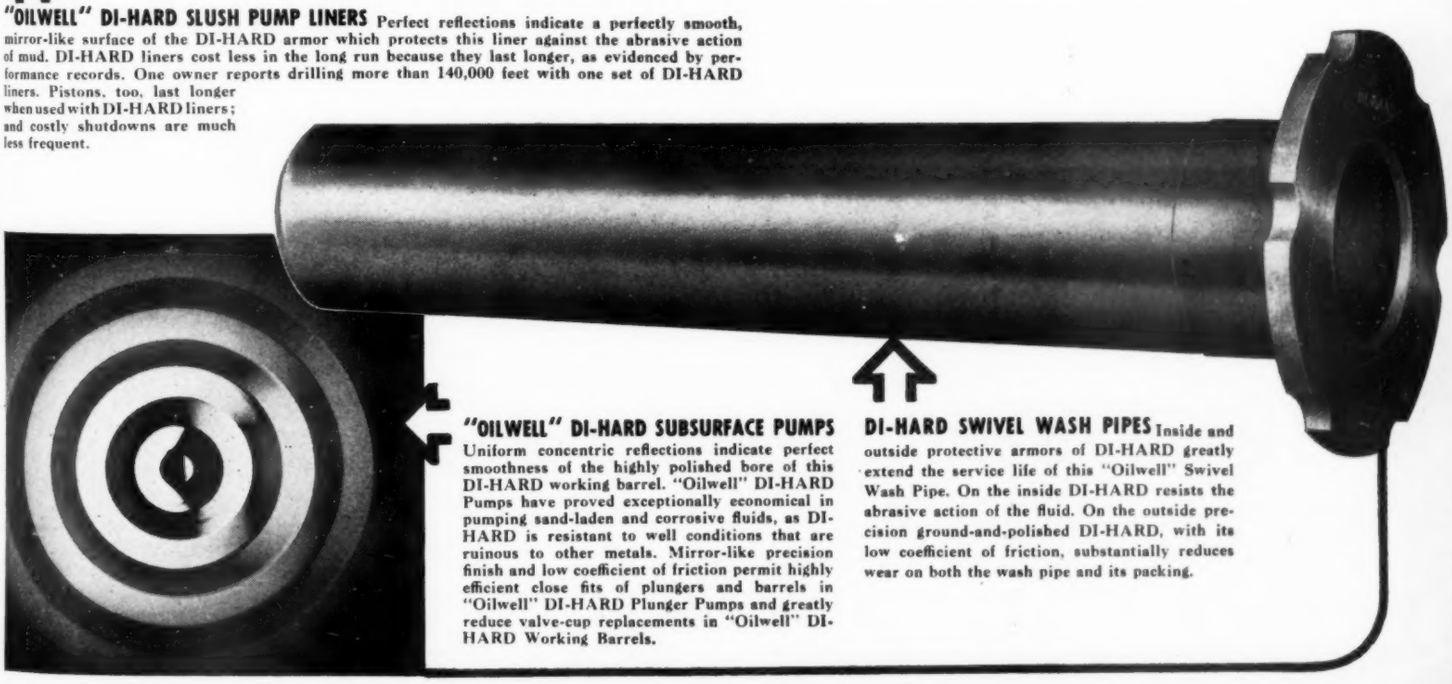

"OILWELL" DI-HARD SUBSURFACE PUMPS Uniform concentric reflections indicate perfect smoothness of the highly polished bore of this DI-HARD working barrel. "Oilwell" DI-HARD Pumps have proved exceptionally economical in pumping sand-laden and corrosive fluids, as DI-HARD is resistant to well conditions that are ruinous to other metals. Mirror-like precision finish and low coefficient of friction permit highly efficient close fits of plungers and barrels in "Oilwell" DI-HARD Plunger Pumps and greatly reduce valve-cup replacements in "Oilwell" DI-HARD Working Barrels.

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OIL WELL SUPPLY COMPANY

Elements of Orifice Meter Operation and Maintenance*

Exclusive

☆ **Designed specifically to aid in training chart changers and plant operators in the development and use of orifice meters, this practical discussion of gas measurement should prove interesting to engineers and others as well**

PART 1

by J. W. J. Bercher

Tide Water Associated-Seaboard Oil Company

THE earliest device showing a definite relationship to the modern orifice meter was the Pitot tube invented in 1750 by Henri Pitot (born, 1695—died, 1771). This device was essentially a curved tube used as a measuring device for determining the velocity of flow of water. An examination of Fig. 1 will give an idea of the construction and use of the Pitot tube.

It will be noted that when one arm of the tube is pointed upstream, the column of water in the vertical leg of the tube will stand at some level B, which is h inches above the level of the flowing water. The velocity could then be found from the relationship $v = \sqrt{2gh}$, where v = velocity, g = 32.17, and h = the observed height. By the use of the proper correction factors the tube might be used for liquids other than water. In cases when turbulence of the surface of flow made it impossible to measure h accurately from the surface, a second tube was used that was turned at a right angle to the direction of flow and the level of the liquid in this tube used as the base from which h was measured.

In the case of gases it would be impossible to measure the height, h, directly by observation, so when the problem of measuring gas flow was encountered, some modifications were necessary and the tube shown in Fig. 2 was evolved. In using this "open flow tester," which is still in use today, the U-tube is filled with some liquid of known density (water, red oil, or mercury) and the displacement of the liquid noted and referred to gas by the use of proper coefficients. In most cases when this device is used, reference is made to a chart that gives the flow in thousands of cu. ft. (M.C.F.) per day based on the size of pipe from which the flow occurs and the displacement of the liquid used.

It might be well to bring out at this point that in reading a U-tube, or manometer, the total displacement is to be read and not the distance above or below the zero of the scale. In other words, add the reading above zero on the high side and the reading below zero on the low side and the sum will be the correct reading even though the zero is not in its proper position relative to the static liquid levels in the two legs of the instrument. If this method is used, any errors due to improper setting of the scale, or due to the manometer being slightly out of plumb, will be compensated so that no serious error will be noted in the result obtained.

When the manometer reading is obtained, it is basically a measure of velocity so that if volume is desired the cross-sectional area of the path of flow must enter into the calculation and the formula becomes $Q = A\sqrt{2gh}$, where Q = quantity, A = cross-sectional area, g = 32.17, and h = the velocity head as measured by the Pitot tube.

As the use of gas as fuel increased, more accurate means for measuring the flow inside pipe lines were needed. In January, 1904, P. C. Oliphant introduced a modification of the Pitot tube that offered a solution of the problem. This early Oliphant Pitot tube is shown schematically in Fig. 3.

Oliphant Tube

The characteristics of this tube were identical with those used in the more refined meter of today. A piece of ⅜-in. iron pipe, L-shaped, was inserted in a 4-in. pipe so that the open end was directly in the center of the pipe. The connection "B" was placed 1 ft. distant from the point "C" and on the upstream side. By means of the gas flowing against the open end, the static and dynamic pressures were transmitted to the "U" tube, and only the static pressure was transmitted from the point "B". In other words, the two static pressures were balanced, and the only thing then left was the dynamic pressure, which caused the water in the "U" tube to rise to the height h. The height of water, h, is, therefore, the pressure that would pro-

J. W. J. BERCHER

attended Missouri School of Mines, Rolla, Missouri, 1926-27; Cameron State Junior College, Lawton, Oklahoma, 1931; Air Corps Technical School, Chanute Field, Illinois, 1932—Employed by various pipe-line contractors, 1925-29—With Sure Shot Torpedo Company, Huntington, West Virginia, 1930—Entered U. S. Army Air Corps, 1931—Employed by Tidal Pipe Line Company, 1935; worked as line walker, clerk, and pumper—Transferred to Tide Water Associated-Seaboard Oil Company's Cayuga Recycling Plant No. 1 as laboratory-meter man in 1938—In 1940 was promoted to assistant plant foreman in charge of Cayuga Recycling Plant No. 2.

*The material presented herewith constitutes the syllabus or text book used by a vocational class in East Texas, members of which were company employees interested primarily in learning more of orifice meter measurements.

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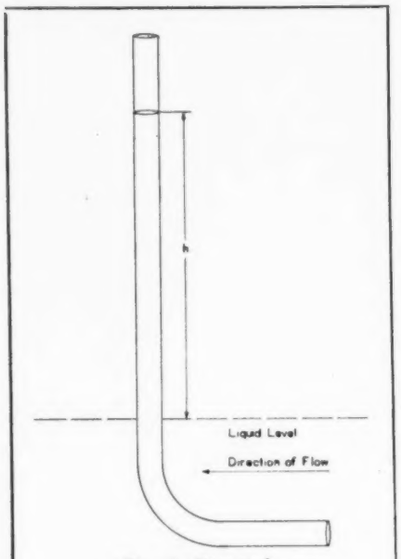


Fig. 1. Pitot tube

duce the velocity, V, of the gas flowing in the pipe line. The static, or gauge pressure, p, was observed by means of a large "U" tube filled with mercury. The Pitot tube was then calibrated and the coefficient for it determined by passing gas into a large gas holder under varying conditions of flow and pressure. Other tubes were then made by comparing them to these tubes, and they proved successful. After a good many years it was determined to make more refined tubes of various sizes, and again calibrate them, using the gas holder, thus giving what is known as Standard Tubes to which all other tubes were compared and their coefficients determined.

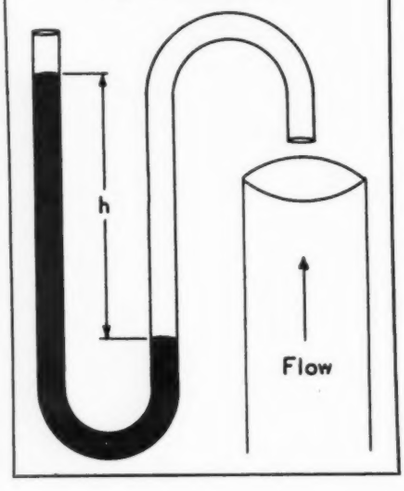
The best use of the Pitot tube was obtained when it was especially designed for permanent installation. When properly constructed and installed, it became a scientific instrument of accurate measurement. It is constructed of a carefully made steel tip, having a hole about ¼-in. in diameter, inserted in the exact center of a seamless drawn brass tube with interior surface highly polished and gauged to accurate and uniform size throughout its length. The tip is mounted in a saddle in such a manner as to be easily removed for cleaning, and easily re-inserted to occupy exactly the same position as before removal. The size of the brass tube used is determined by the quantity of gas to be measured, and is so chosen as to produce velocities much higher than those encoutered in the main pipe lines, in order to give a high differential or impact pressure reading, thus greatly increasing the accuracy of the instrument by diminishing the error of observation. Each tube must be calibrated against a standard tube and a coefficient obtained, which, when multiplied by the square root of the product of the differential pressure and the static pressure (in absolute units), will give the flow in unit time.

These high precision tubes were usually installed in batteries of two or more, for obtaining measurements of a wide range of flows and had a sufficient run of pipe, both upstream and downstream, to avoid eddies and counter-currents in the flow. The polished interior surface of the tube, and the high velocity of the gas prevented the formation of deposits and the tube coefficient remained constant for a long period. Should any accident occur whereby the tube became dented or injured in any way, it was necessary to have it repaired and recalibrated to obtain a new coefficient.

The Pitot tube usually was used with readings as high as 30 or even 36 inches of water. Above this value the "U" gauge became cumbersome. It is not practicable to use it with a differential lower than 1 inch of water, as at this value an error of observation of 0.02 inches will produce an error in Q of 1 percent. Its practical working range is therefore 5 to 1, i.e., it will give values within 1 percent of correct from maximum capacity down to one-fifth maximum. For very accurate work this range is usually cut down to about 4 to 1, corresponding to a minimum water reading of about 2.25 inches. In other words, a tube with a capacity of 100,000 cu. ft. per hour at a certain pressure would be accurate for flow rates as low as 25,000 cu. ft. per hr., as a minimum.

In January, 1910, B. C. Oliphant found the need of a Pitot tube that could be quickly and easily transported from place to place in the gas fields in order to keep a careful check on gas

Fig. 2. Manometer



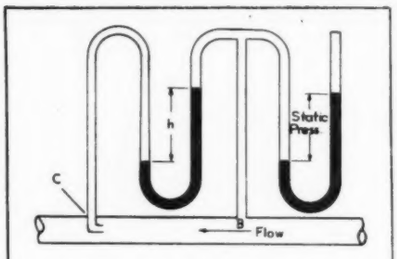


Fig. 3. Oliphant Pitot tube

wells to determine whether their flow was diminishing or not, while under working conditions. This brought about the invention of the Pitot Tip and Box. In this arrangement, the box was attached to the pipe line leading from the well and when not in use the tip was withdrawn and the opening plugged with a common pipe plug. To the lines from individual wells similar boxes were fitted and the gauge was carried from one location to another with little inconvenience.

As the regular pipe line was used instead of a special 12-ft. length of drilled brass tubing the same size of the line, the error was greater than with the perfected Oliphant Pitot tube, but it served its purpose to a high degree of satisfaction.

It is interesting to note the gradual change from the original Oliphant Pitot tube to the present-day orifice meter.

First Orifice Meter

The Pitot Tip and Box did not come into general use, but from it and the Pitot tube came the orifice meter, invented in 1911 by John G. Pew and H. C. Cooper. Although the Pitot tube is considered a very accurate measuring instrument, the high cost of installation and inability to transport it easily from one location to another in the gas field caused it to be displaced by the smaller and more readily moved orifice meter with its self-recording differential gauge.

The invention of the recording differential gauge was also the direct result of the objectionable high upkeep of the old Pitot tube. The recording differential gauge now does the duty formerly done by the employees working double shift, who read the water gauge every 15 minutes throughout the 24 hours and mailed their handwritten reports to the main office daily.

EDITOR'S NOTE: This article will be continued in a subsequent issue.

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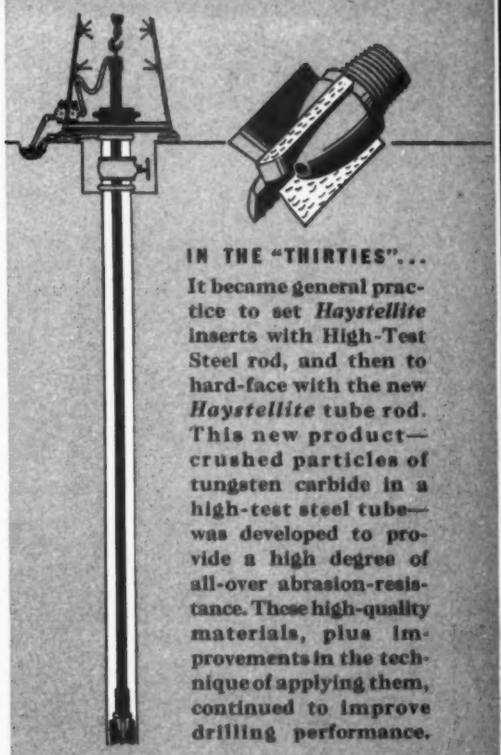
Haynes Stellite Products
for more efficient drilling tools

IN THE EARLY "TWENTIES"...
Haynes Stellite Company introduced the practice of hard-facing oil well drilling bits with *Haynes Stellite* rod—and fishtail bits hard-faced with this non-ferrous alloy soon were making unprecedented drilling records in oil fields everywhere.

IN THE LATE "TWENTIES"...
The newly developed *Haystellite* cast tungsten carbide inserts were introduced and adopted for hard-setting drilling tools. Again drilling records were shattered as these diamond-hard inserts made what was then almost unbelievable footage.



IN THE "THIRTIES"...
It became general practice to set *Haystellite* inserts with High-Test Steel rod, and then to hard-face with the new *Haystellite* tube rod. This new product—crushed particles of tungsten carbide in a high-test steel tube—was developed to provide a high degree of all-over abrasion-resistance. These high-quality materials, plus improvements in the technique of applying them, continued to improve drilling performance.

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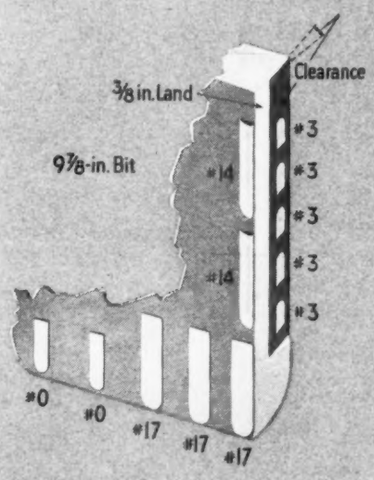

Shown above is a typical application of Haystellite inserts.

AND IN THE "FORTIES"... Bits hard-set with *Haystellite* inserts and hard-faced with *Haystellite* tube rod are still making outstanding drilling records. As new types and sizes of bits have been developed, Haynes Stellite Company has brought out additional sizes and shapes of uniformly hard and tough Haystellite inserts to fit them. Constant research work on hard-setting and hard-facing materials and on methods of applying them assures continued progress in the future.

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Small Gun Perforator Aids in Solving Production Problem

☆ Small bullets—1/8-in. and 1/16-in.—can now be shot through tubing as small as 2-in., penetrating only one string

by H. Lee Flood
Associate Editor

ONE of the most interesting tools recently made available to the production division of the oil industry is the small gun perforator designed for use inside tubing strings as small as 2 in. Its interest lies in the fact that it can be employed for a number of different purposes, not the least important of which involves "getting out of trouble" when the tubing string is stuck in the hole.

The external diameter of the gun body is only 1¾ in. Until this gun was developed, no one had successfully designed a gun this small because the thinking was still in terms of placing the powder charge horizontally (normal to the long axis of the gun). In a small gun, the limited space prohibited use of a sufficiently large charge of powder to be effective.

In the new gun, this previous difficulty was circumvented by placing the powder charge vertically (parallel with the long axis of the gun). Inasmuch as the bullet is placed (as in the normal arrangement) to shoot horizontally, the designers of the gun have literally achieved the feat of "shooting around a corner."

The 1¾-in. gun perforator was developed in the West Texas area primarily in answer to the need for a means of perforating tubing for gas-oil ratio control purposes without the necessity of removing the tubing from the hole. In many of the older fields in West Texas, canvas or other types of packers were installed in wells. Although these packers in many instances have served effectively for years, it is not economically feasible to rerun such packers assuming that they could be removed without destroying them. The removal of these old packers has also proved to be a very costly operation in some areas, and after their removal there has been difficulty in obtaining another packer seat.

Although the method is not so widely used in other areas, in West Texas, following the leadership of one of the larger operators, it has been the practice for several years to pull the tubing string and drill small orifices in the tubing collars. When the tubing is rerun, these drilled collars are spaced in the string to serve as points of admission for gas from the annular space into the tubing to aid in lifting the fluid.

Preparing to perforate 2-in. external-upset tubing with 1/16-in. bullet above packer in well in Monument Pool, Lea County, New Mexico. In foreground, gun is made up ready to run-in well. After perforation, well flowed with satisfactory gas-oil ratio

Because the amount of gas admitted through even a small orifice represents a considerable volume, the holes drilled in the collars are not large.

As a part of developing the 1¾-in. gun for this service, two new bullet sizes were designed, 1/16 in. and ⅛ in. in diameter, respectively. The largest bullet that can be fired from the small gun is 15/32 in. in diameter. An important requirement in designing the small gun was to specify a powder charge having sufficient explosive energy to fire the bullet through one tubing wall without penetrating or damaging other tubing or casing strings.

Perforating for Gas Admission

The usual plan, when high-pressure gas is available from a compressor plant or other external source, is to perforate the tubing string with single ⅛-in. holes spaced 400 ft. apart. When formation gas from above a packer is to be used for lifting purposes, the practice is to perforate with 1/16-in. bullets, the number and spacing often being determined progressively in order to conserve as much gas as possible.

Freeing Stuck Tubing

In one instance recently, use of the small gun saved untold hours of work that might have been expended trying to free a string of tubing. Following the fairly extensive practice in West Texas of using tubing as a drill string to clean-out or drill a well deeper, a string of 2½-in. tubing was in use in the well in question. As the driller started out of the hole, cavings balled-up above the bit and caused the tubing to stick. Various methods were tried in an effort to jar the pipe loose but it would neither move upward nor downward nor could circulation be established. Knowing the small gun was

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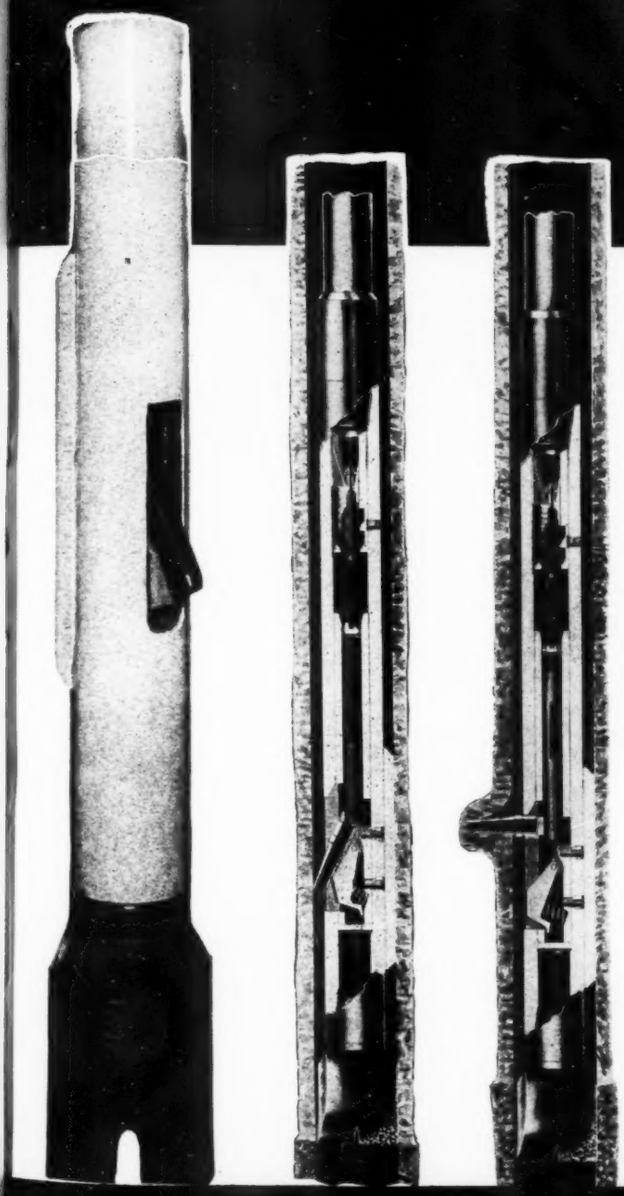

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The tool is run in the hole on drill pipe. Cores are recovered by means of the retractable wire line barrel and wire line overshot. Any number of cores may be taken, and they range in size up to 1¾" diameter by 8" length. Any type bit desired may be installed on the lower end of the tool for drilling out bridges when necessary. A circulation plug may be dropped into the tool so that circulation can be maintained to the bit whenever desired.

Left: **Showing the tool, with wire line retractable barrel in position to receive the core.**

Center: **Core tube deflected, ready to penetrate side wall to take core.**

Right: **Core tube in side wall after lowering of drill pipe has caused penetration. Drill pipe is now slightly raised, and core recovered by wire line.**

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available, the operator called out the perforating truck, specifying the use of the 1¾-in. gun. Within 4 hours from the time the truck was called, a 15/32-in. hole had been shot through the tubing near the top of the caved material, circulation had been established, and the tubing was freed.

In another instance, it was impossible to remove the tubing string from a well because the packer would not free itself. In addition to this, an anhydrite ring had formed between the tubing and casing, completely closing the annulus and trapping high-pressure gas between the anhydrite and the packer. Anhydrite formations of this type are encountered frequently in West Texas wells but they usually can be dissolved readily by dumping water in the well. In this case, however, water had little or no effect on the anhydrite.

Having determined the approximate location of the anhydrite ring based on the volume of water required to fill the annulus, the 1¾-in. gun was lowered in the well and a 15/32-in. bullet was shot through the tubing between the anhydrite ring and the packer, thus releasing the trapped gas into the tubing. Following this, the tubing was cut above the packer and removed from the hole.

Other Uses

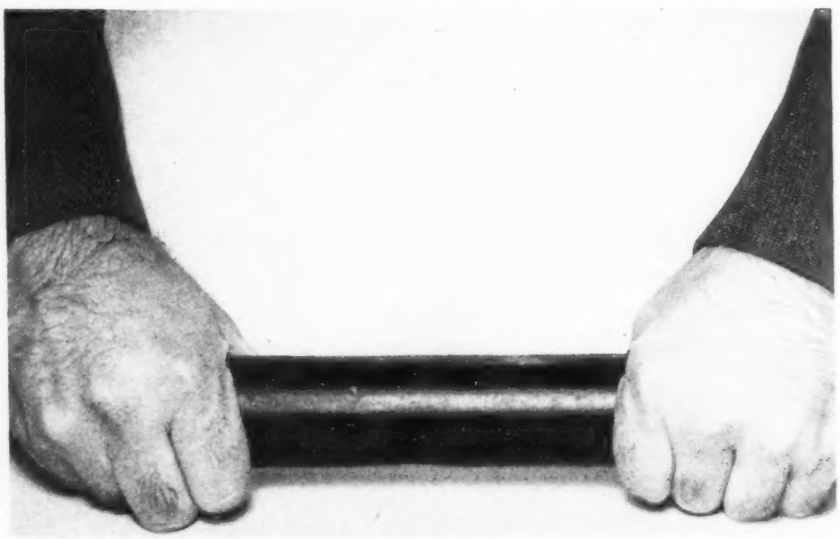
The 1¾-in. gun has been used quite extensively in West Texas wells, considering the short time this tool has been available.

When so many production problems arise that involve the need for creating an opening between two tubular strings in a well, quickly and of definite size, there are any number of applications for the small gun that readily occur to the experienced production engineer.

Another application of its use is in cases where a packer has been stuck by mud or other material settling on top of it. Perforations have been made just above the packer to provide a means of circulating to wash and remove this material.

The 1¾-in. gun inserted in a section of 2-in. tubing in which a 1/16-in. hole has been shot. The muzzle of the gun appears on the body of the gun

Showing one of the gun barrel muzzles in the body of the 1¾-in. gun



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Laboratory Study of Water Encroachment in Oil-Filled Sand Columns

RECOGNIZING that the ultimate quantity of oil that may be recovered economically from oil fields may be increased as a result of a better understanding of water encroachment in oil-bearing sands and rocks, the U. S. Bureau of Mines is conducting a laboratory study of the part water plays in oil production. The Bureau's study to date reveals that under certain idealized laboratory conditions and within a range of water movement of the same order of magnitude as rates of edgewater encroachment in oil-bearing structures the percentage of oil recovered increases with the rate of water movement.

Although this conclusion is based upon the results of one series of many contemplated laboratory experiments it is significant because oil-recovery efficiencies in fields having effective natural waterdrives generally are believed to bear an inverse relationship to the rate of water encroachment. Bureau engineers appreciate that oil-recovery efficiencies effected by waterdrives probably depend on several variables, but only the rate of water movement was considered in the study made so far.

The experiments were performed by flooding with water-packed, oil-filled columns of unconsolidated quartz sand of a grain-size range within the limits of many naturally occurring oil sands. The experimental apparatus permitted accurate control of the test temperature and the slow rates of water-flooding used. Visual observations of the sand columns were made during experimentation. The results of the experiments, together with drawings, photographs and charts, are given in Bureau of Mines Report of Investigation 3595, "A Laboratory Study of Water Encroachment in Oil-Filled Sand Columns," by Frank G. Miller. Copies may be obtained without charge from the U. S. Bureau of Mines, Department of the Interior, Washington, D. C.

The NEW SPERRY-SUN

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(Electro-Chemical)

INCLINOMETER

U. S. Patents 2,240,417; 2,246,319 and Others Pending

You've never seen anything like the new Sperry-Sun E-C Inclinometer. It's as different from present-day recording instruments as day from night. Operated by dry-cell batteries on sound electro-chemical principles, it opens up entirely new possibilities in well surveys—giving you a means to faster and more effective drilling.

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★

FACTS ABOUT THIS SPECTACULAR NEW INSTRUMENT

Self-Checking. Simply can't produce a false record.

No timing device needed. No trouble with clocks or synchronized watches.

Minimum recording time. Produces accurate records in as little as 45 seconds. Can be lowered and raised at 800-1000 feet per minute.

Operates on ordinary measuring line. Outside diameter only 1-5/16". Passes through any tool joint.

Permanent records—instantly. Can be read immediately on removal. No development required. Records are permanent and indestructible.

Multiple recording. Several records at various depths can be made each time the instrument is lowered into the hole.

Reasonable rental charges. No higher than those of other inclinometers which are not self-checking and do not permit multiple recording.

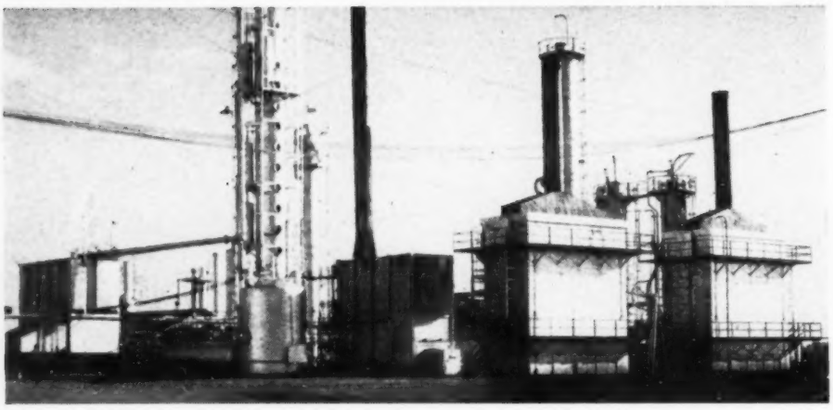
Lowest operating cost. Minimum loss of rig time.

SAMPLE RECORD

Note difference in size of white dots. Size of dot depends on length of time instrument is allowed to remain at rest. Thus records can be made at several different depths, and the record at any depth definitely identified by the size of the dot.

SPERRY-SUN WELL SURVEYING CO. 1608 WALNUT ST., PHILA., PA.

Branch Offices: Houston, Lubbock, Corpus Christi and Fort Worth, Texas; Oklahoma City, Okla.; Long Beach and Bakersfield, Calif.; Lafayette, La.



Petreco unit is shown directly in front of the topping column and beside the topping furnace

Salt Removal From Refinery Charging Stock

☆ **Equipment in Michigan refinery effectively reduces salt content from 125 lb. to 6 lb. per 1000 bbl. of crude oil**

by J. C. Albright

THE problems that confronted Leonard Refineries, Inc., at its Alma, Michigan plant, when processing the average Michigan crude from which the salts were not removed to the irreducible minimum, were the short-time runs and all too frequent cleaning of equipment plus the degradation of the liquid products. The amount of salts in the form of NaCl in Michigan crude delivered to the refinery at Alma averages about 125 lb. per 1000 bbl., part of which can be washed out by the common method of heating with added water and settling in a horizontal drum. The runs at this plant, which should have lasted over periods of weeks, were reduced to an average of 10 to 14 days, and washing of the crude fractionating column was done weekly with water. The tubes in the crude oil heater also required cleaning weekly to remove the fouling. The capacity of the plant was rated at 2300 bbl. of fresh crude as charged to the topping unit, and the cracking plant was rated at 1100 bbl. of topped crude per day.

Corrosion of the upper part of the topping column resulted in replacement of bubble trays and caps, and overhead condensers required expensive replacement of parts. The products of the plant, particularly the kerosine cut, were difficult to treat and the color was unstable. In addition, a sample of kerosine left in a common 4-oz. bottle exposed to average light intensity showed a fine white deposition in the bottom, and when testing with the standard lamp, the chimney accumulated a greyish-white glaze that reduced the amount of illumination normally expected from this illuminant.

J. C. ALBRIGHT

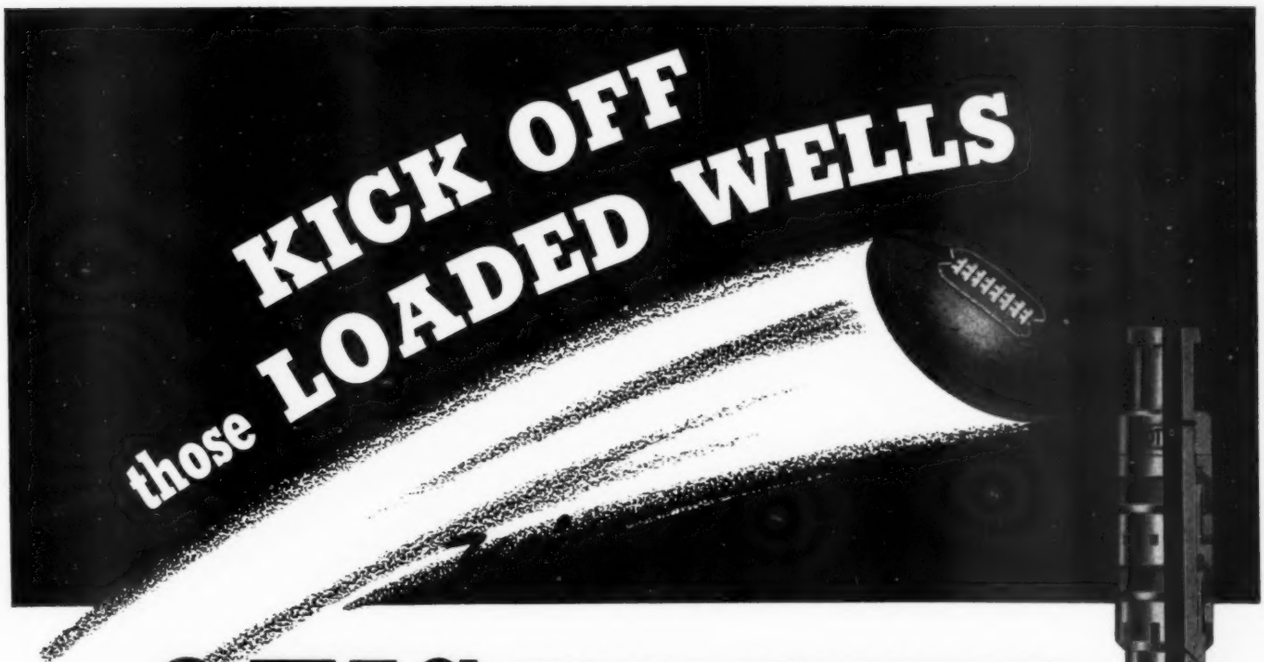
for last 12 years has devoted virtually all his time to free-lance writing for trade journals—Began his career as drilling superintendent for H. J. von Hagen in North Texas area, 1919-1921—With the Noble Oil and Gas Company, Burkburnett, Texas, from 1921 to 1923—Joined staff of the Dixie Gasoline Company in 1923 and became Texas manager—Employed by Phillips Petroleum Company in 1925 and was sent to New Mexico, where the company constructed a natural gasoline plant—Left Phillips in 1929 and for a time operated as a consulting engineer before taking up writing.

Salt Removal

After all methods available at the plant had been tried and discarded, one after another, a Petreco dehydration and desalting unit was installed. The equipment remaining at the plant in service for salt reduction consisted of a crude oil exchanger and a settling tank of large capacity installed horizontally in the charge line from the crude oil pump to the tubular heater in the skimming section of the plant. The Petreco unit was stepped into this crude charge line, between the heat exchanger and the horizontal settling drum, so that the temperature of the crude might be raised high enough for effective desalting and also to provide an extra settling vessel for the crude oil before it entered the topping furnace.

Flow

Running on Michigan crude oil containing the average amount of salt, the flow through the apparatus is as follows: The crude is picked up from the plant storage tanks by the crude charge pump and pumped through the commodity exchanger to raise the temperature to 190°F. Water is pumped into the line carrying the hot crude so that for each 1000 bbl. of crude oil handled, 150 bbl. of water is used.



OTIS TUBING PERFORATOR AND PACKOFF ANCHOR

- ★ **NO tubing to pull — Packer seal not broken.**
- ★ **NO mud or water exposed to sand face.**
- ★ **NO swabbing necessary.**

THE Otis Wire Line Tubing Perforator and Packoff Anchor provide a means for kicking off loaded wells where casing annulus is sealed with a packer. The job is done under pressure without pulling the tubing, breaking the packer seal or exposing the lower pay to mud or water.

The operation is simple. The Otis tubing stop is set in the tubing above the packer. It serves as a base for the perforator and later as an anchor for the packoff section. A back pressure valve is dropped in on top of the stop to prohibit the mud or water back of the packer from contaminating the pay formation. The tubing is then perforated. All mud or water is circulated out of the casing annulus through the perforations. The back pressure valve is pulled and the removable packoff section set in place with the orifices matching the tubing perforations to control the rate of flow through them.

The column of oil is started flowing by gas pressure applied through casing annulus from an overlying formation or from an outside source. Conventional Otis running and pulling tools are used to run and pull the packoff section and anchor stop. Experienced Otis Service Crews are available on short notice to do this work quickly, efficiently and economically.

Write for Complete Information and Details

OTIS PRESSURE CONTROL, INC.
DALLAS, TEXAS

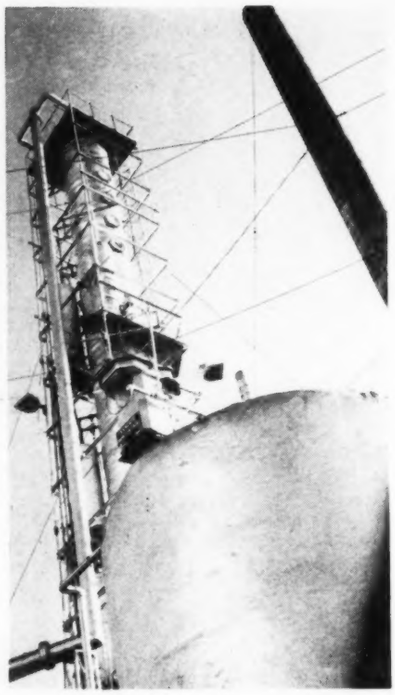
Branches: New Iberia, Louisiana; Houston, Texas; Hobbs, N. M.
Representatives: Otis Eastern Service, Inc.; Wellsville, New York; Western Pressure Control, Inc., Los Angeles, California
Export Office: 74 Trinity Place, New York City

PRESSURE CONTROL · OTIS · SERVICE - EQUIPMENT

This water is injected into the commodity line between the heat exchanger and the Petreco unit, and is mixed intimately with the crude through a back-pressure valve, which creates a high turbulence and high velocity in the oil and water. As the emulsion enters the desalting vessel, the electrified zone causes rapid deposition of water, which is withdrawn from the base and dumped to the plant disposal lines. Oil flowing from the top of the unit enters the horizontal drum and thence goes to the topping furnace.

Results obtained by treating the charging stocks by this method are:

(1) Reduction of NaCl from 125 lb. per 1000 bbl. to an average of 6 lb. per 1000 bbl.;
(2) Increased running time, which has been extended from the low of 10 to 14 days to an average of 60 days without difficulty;



Looking past transformers on desalting unit toward topping column

(3) Lowered maintenance. The topping column is washed only when required (every 6 months or so) and crude furnace tubes seldom show coke or deposition of foreign material;
(4) Improved products. Kerosine produced from crude containing only 6 lb. of NaCl per 1000 bbl. burns in test lamps with no glaze on the chimneys, and test bottles exposed to light of any intensity are free from the fine white sediment formerly found.

Runs at the plant, formerly 2300 bbl. per day to the topping plant, have been increased to 2800 bbl. and the cracking plant operates easily on 1300 bbl. of topped crude charge; formerly only 1100 bbl. could be cracked. By removing the salt from the crude, tower-top fouling and corrosion of plates and bubble caps have been almost eliminated, vapor condensing units require a minimum of replacement and cleaning, and treating of the products is simpler.

☆☆☆

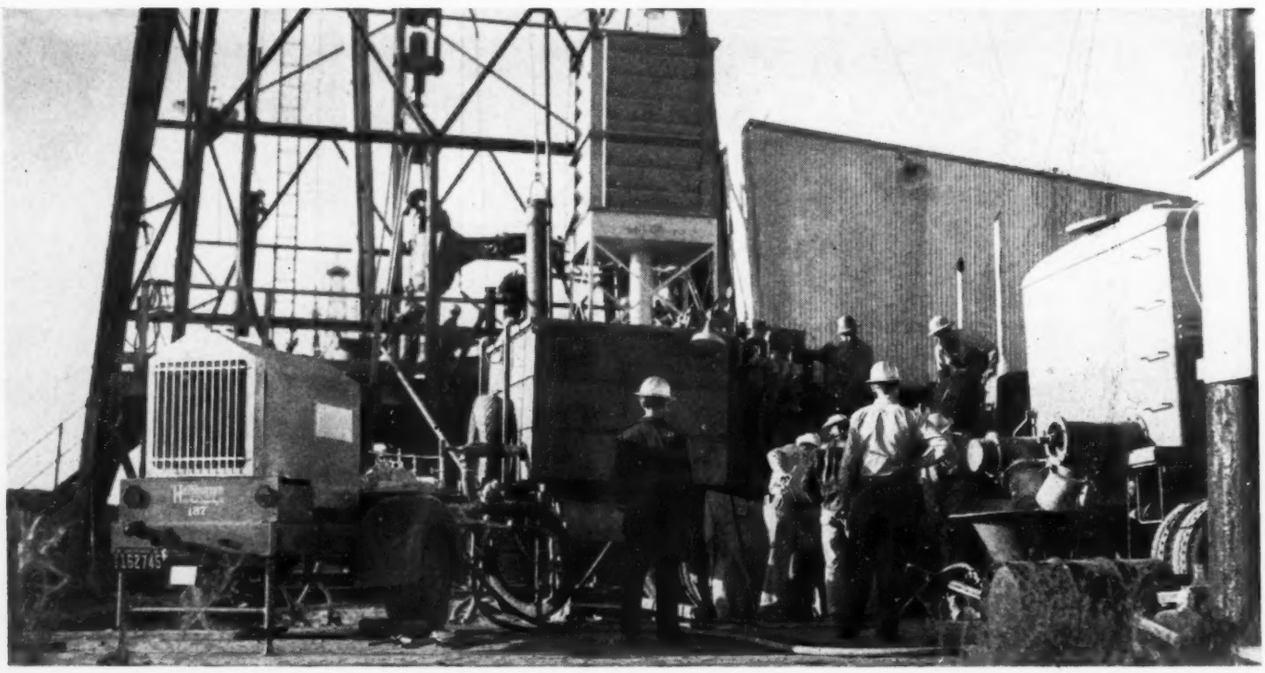
P 444.2

Trailer-Mounted Centrifugal Pump Used With High-Pressure Power Cementing Outfit

THE Halliburton Oil Well Cementing Company has recently introduced in California a trailer-mounted centrifugal pump for use in connection with a high-pressure power cementing outfit, to offer the same advantages of speed, safety, and pressure in a power outfit as they have been offering for many years with their three-pump steam outfits.

The use of this three-pump power outfit, together with cement delivered in bulk, makes it possible to mix cement at speeds of better than 50 sacks per minute. It offers a safety factor in that any one of three pumps might fail without preventing successful completion of the job. This unit is supplied wherever speed plus safety is essential.

Halliburton trailer-mounted centrifugal pump



Speakers table at Thursday luncheon. Left to right: A. S. Ritchie, McPherson Drilling Company, Wichita, Kansas; Leslie Fain, Fain Drilling Company, Oklahoma City, Oklahoma; John J. Klise, Kenrow Company, Wooster, Ohio; J. E. Brantly, Drilling and Exploration Company, Inc., Los Angeles, California; E. B. Rubsamen, Jr., Trinity Drilling Company, San Antonio, Texas; Harry L. Edwards, vice-president at large, who presided at the Friday morning meeting, and Wm. D. McBee, M. J. Delaney Company, Dallas, Texas

Drilling Contractors Meet in Dallas

THE American Association of Oilwell Drilling Contractors held its first annual convention in Dallas, Texas, on November 13 and 14. Approximately 250 drilling contractors from all parts of the United States were in attendance.

Some of those in attendance are shown on this and the two following pages.

The program was arranged with a view to showing the drilling contractor the value of coöperative effort. Under discussion were such questions and problems as labor relations, wages and hours, organization of local chapters of the association, priorities, employees' welfare, transportation and highway relations, drilling and contract forms, compensation insurance, safety engineering, drilling practices, improvement and equipment, membership rates, accounting, railroad freight rates, policy, taxes, cable-tool practices, and relations with other associations.

Officers of the association are: J. E. Brantly, Los Angeles, California, president; Harry L. Edwards, Houston, Texas, vice-president at large; Warren S. Churchill, Tulsa, Oklahoma, vice-president for rotary drilling; John J. Klise, Wooster, Ohio, vice-president for cable tools; C. J. Paine, Dallas, treasurer, and Brad Mills, Dallas, secretary.

The Executive Committee is composed of J. E. Brantly, Harry L. Edwards, Warren S. Churchill, John J. Klise, C. J. Paine, Leslie Fain, Oklahoma City, Oklahoma, and Will I. Lewis, Mt. Vernon, Illinois.

John A. Chapman (left), Gray-Wolfe Drilling Company, Houston, Texas, chairman of the Drilling Equipment Committee, and Anthony F. Keating, Robey-Keating Drilling Company, Tulsa, Oklahoma

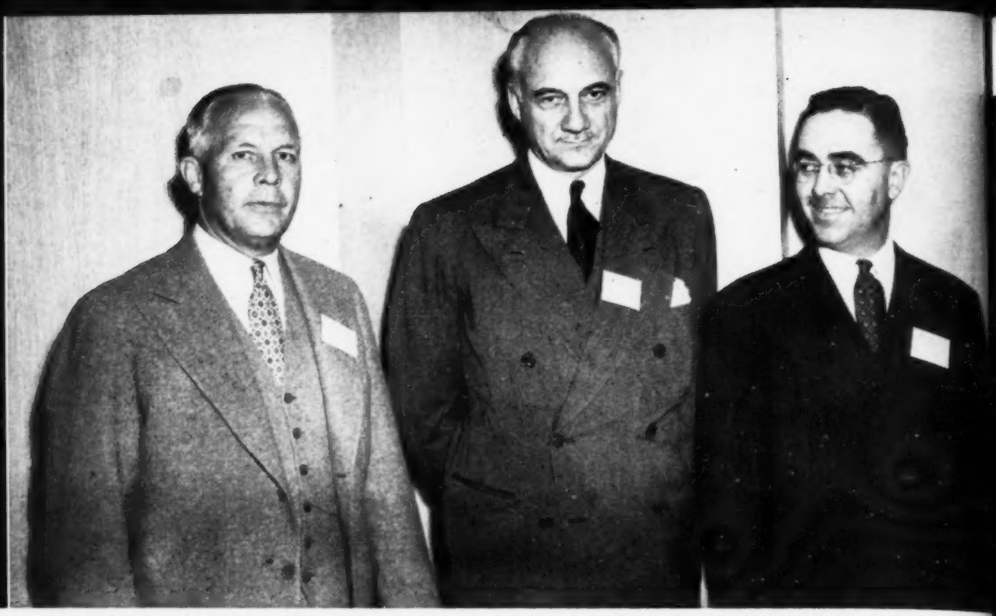
John W. McKnab, McKnab Drilling Company, Winfield, Kansas

Will I. Lewis, Mt. Vernon, Illinois, director at large and a member of the Dues Committee

A. S. Ritchie, McPherson Drilling Company, Wichita, Kansas, chairman of the Taxes Committee

Geo. P. Livermore (left), Geo. P. Livermore, Inc., Midland, Texas, chairman of the Drilling Practices Committee; D. A. Powell, Drilling and Exploration Company, Inc., Hobbs, New Mexico

Brad Mills, secretary, American Association of Oilwell Drilling Contractors, Dallas, Texas, and Lawrence E. Smith, Independent Petroleum Association of America, Tulsa, Oklahoma



E. B. Rubsamen, Jr., Trinity Drilling Company, San Antonio, Texas, regional director Gulf Coastal Region, who presided at the Thursday afternoon meeting; J. E. Brantly, president of Drilling and Exploration Company, Inc., Los Angeles, California, and president of the American Association of Oilwell Drilling Contractors; C. J. Paine, treasurer, American Association of Oilwell Drilling Contractors, Dallas, Texas, and a member of the Dues Committee

Committee members and guests who attended the Public Relations Meeting. Left to right: Howard P. Holmes, Two States Drilling Company, Dallas, Texas, chairman of the committee; E. B. Rubsamen, Jr., Trinity Drilling Company, San Antonio, Texas; Wm. D. McBee, M. J. Delaney Company, Dallas, Texas—members of the committee. Leslie Fain, Fain Drilling Company, Oklahoma City, director at large

R. C. Riggs (left), Dallas, Texas, and L. B. Birckhead, South Milwaukee, Wisconsin, both with Bucyrus-Erie Company

B. F. King, Pacific Employers' Insurance Company, Houston, Texas, who presented a paper, "Compensation Insurance," at the Thursday afternoon meeting; I. H. Patton, Arrow Drilling Company, Tulsa, Oklahoma; Geo. H. Lang, Manahan Drilling Company, Tulsa, Oklahoma

Percy Bosworth, Bosworth Drilling Company, Odessa, Texas; Will I. Lewis, Mt. Vernon, Illinois, director at large and a member of the Dues Committee; Anthony F. Keating, Robey-Keating Drilling Company, Tulsa, Oklahoma; C. W. Denton, Trinity Drilling Company, Dallas, Texas, and a member of the Priorities Committee

Left to right: R. W. Adams, Adams and McGahey, Amarillo, Texas; H. M. Reigle, Richmond Drilling Company, Midland, Texas; W. A. Brown, J. I. Roberts Drilling Company, Shreveport, Louisiana; M. C. Yeaman, L. W. Prunty Drilling Company, Inc., Ponca City, Oklahoma

John J. Klise, Kenrow Company, Wooster, Ohio, one of the regional directors of the Appalachian Region of the Association, registering; H. A. and G. E. Peterson, Drilling and Exploration Company, Inc., Dallas, Texas

Committee members and guests who attended the Drilling Practices Committee meeting: Seated—R. (Cotton) Makin, Carl Short, Inc., Fort Worth, Texas, C. P. Parsons, Halliburton Oil Well Cementing Company, Duncan, Oklahoma; Geo. P. Livermore, Geo. P. Livermore, Inc., Midland, Texas, chairman of the Drilling Practices Committee; R. W. Marshall, Drilling and Exploration Company, Inc., Los Angeles, California, committee member; Dan L. Clark, Dan L. Clark Drilling Company, Corpus Christi, Texas. Standing—Anthony F. Keating, Robey-Keating Drilling Company, Tulsa, Oklahoma; Geo. H. Lang, Manahan Drilling Company, Tulsa, Oklahoma, committee member; R. D. Creighton and E. Trippe, Manahan Drilling Company, Tulsa, Oklahoma; John M. Shimer, Equipment Engineers, Inc., Dallas, Texas, who delivered a paper on "Trends in Drilling Machinery and Equipment" at the Friday morning session; W. J. Jackson, Lane-Wells Company, Dallas, Texas; C. W. DeLancey, Humble Oil and Refining Company, Houston, Texas, who presented a paper on "Drilling Practices" at the Friday morning meeting

A. I. M. E. Meetings

Dallas—Los Angeles

John R. Suman, vice-president of the Humble Oil and Refining Company and president of the Petroleum Division, A.I.M.E., delivers the opening address at Dallas

W. B. Heroy (left) president, Pilgrim Exploration Company, and T. V. Moore, Humble Oil and Refining Company, Houston, check their hats (Dallas meeting)

Upper: Dr. Eugene Stephenson (left) of the University of Kansas, and Chester Naramore, executive secretary of the Petrolum Division, A.I.M.E., at the registration desk, Los Angeles meeting. Lower: Clarence Coberly of Kobe, Incorporated, registers at Los Angeles

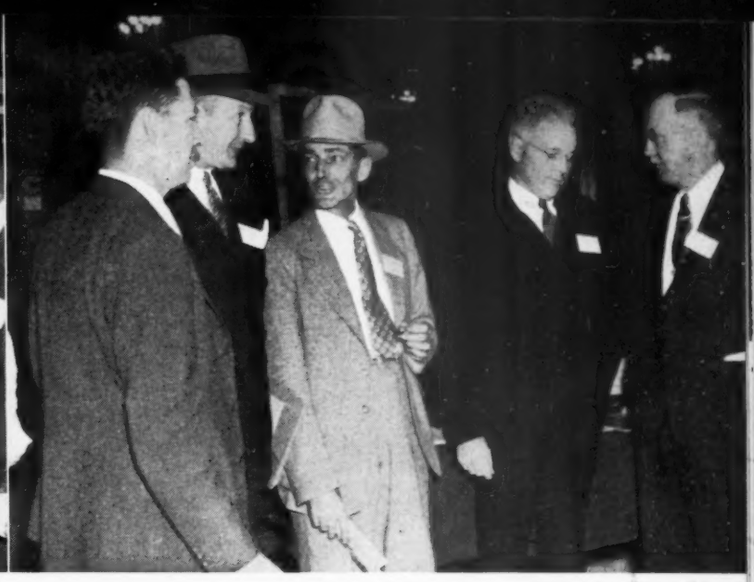
B. C. Craft (left), associate professor of petroleum engineering, Louisiana State University; Mrs. Bugbee, and James M. Bugbee, Baroid Sales Division, Houston, Texas, at E. L. DeGolyer's party during Dallas A.I.M.E. meeting

At the Dallas meeting (left to right): J. U. Teague, Hogg Oil Company, Houston, chairman, Gulf Coast Section, A.I.M.E.; L. E. Tracy, sales manager, Mid-West Division, Oil Well Supply Company, and W. S. (Buck) Morris, chairman of the East Texas Engineering Committee, Kilgore, Texas

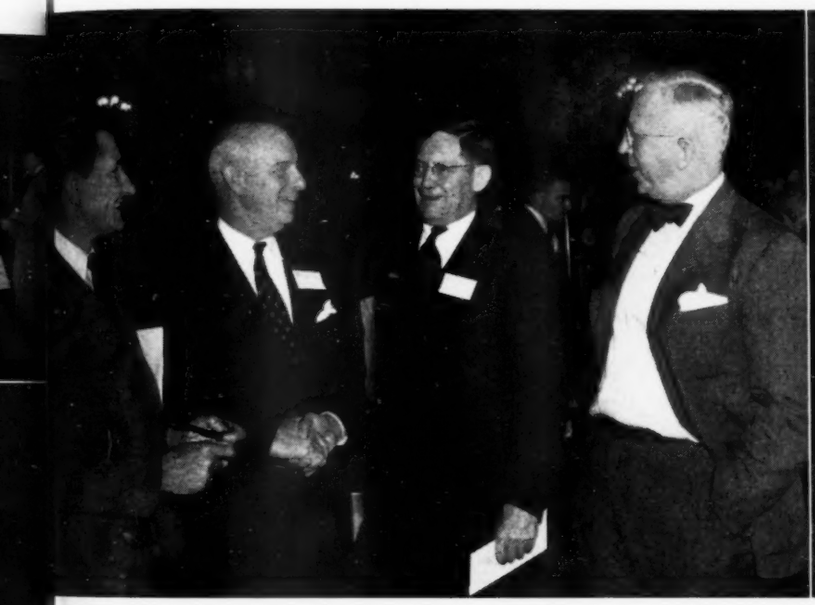
E. R. Brann (left), assistant divisional director of production, Office of Petroleum Co-ordinator, Washington, D. C., and Robert E. Allen, director of production, O.P.C., Washington, D. C., were in attendance at the Dallas meeting

N. N. Jones (left), Humble Oil and Refining Company, Tyler, Texas, and A. W. Walker, Stanolind Oil and Gas Company, Tulsa, at the Dallas meeting

C. A. Warner, Houston Oil Company, Houston (left); E. L. DeGolyer, DeGolyer-MacNaughton and McGhee, Dallas; Gordon Fisher, Gulf Oil Corporation, Fort Worth, Texas, and George R. Brown, Brown and Root, Houston, gather in DeGolyer's library during a party given at his Dallas home for A.I.M.E. members.



Left to right: John S. Bell, division petroleum engineer, Humble Oil and Refining Company, Wichita Falls, Texas; C. P. Parsons, vice-president, Halliburton Oil Well Cementing Company, Duncan, Oklahoma; C. A. Warner, Houston Oil Company, Houston; George B. Corless, general superintendent, Gulf Coast Division, Humble Oil and Refining Company, Houston, and E. J. Kennedy, Jr., assistant to the secretary, A.I.M.E., New York City (Dallas meeting)



Enjoying a pleasantry at the Dallas meeting are (left to right): Dr. George Fancher, professor of petroleum engineering, University of Texas; W. B. Heroy, president, Pilgrim Exploration Company, Houston, Texas; A. B. Parsons, secretary A.I.M.E., New York City, and Francis E. Heath, Sun Oil Company, Dallas, Texas

Talking things over at the Dallas meeting. Left to right: John G. Campbell, Houston Laboratories, Houston; W. A. Leech, Jr., Koppers Company, Tulsa, Oklahoma; Laurance S. Reid, Oklahoma Geological Survey and associate professor at the University of Oklahoma; Thomas S. Bacon, Lone Star Gas Company, Dallas, and Kenneth Eilerts, U. S. Bureau of Mines, Bartlesville, Oklahoma

Banquet of Petroleum Division of A.I.M.E., held in Fiesta Room, Ambassador Hotel, Los Angeles, California

Spindletop Anniversary

Celebrated by Texas Mid-Continent Oil and Gas Association

The association's new president, George Sawtelle of Houston (shown at the speaker's stand), tells a story. From left to right are: Charles P. McGaha of Wichita Falls, president of the National Stripper Well Association and former president of the Texas Mid-Continent Oil and Gas Association; John F. O'Donohoe, seated, of Wichita Falls, who was awarded one of the Texas Mid-Continent distinguished service awards; John R. Suman of Houston, vice-president of the Humble Oil and Refining Company, and president of the American Institute of Mining and Metallurgical Engineers, who was awarded the other, and President Sawtelle

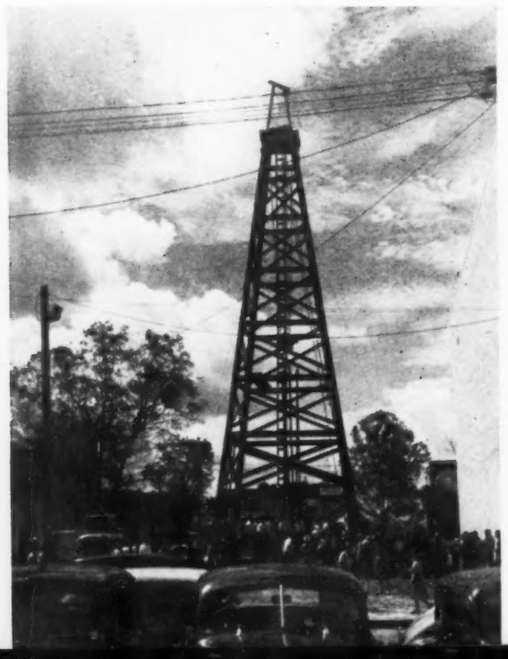
The executive heads of the Texas Mid-Continent Oil and Gas Association get together with a former president. At the right is George Sawtelle of Houston, new president; center is George C. Gibbons of Dallas, executive vice-president, and left, Charles P. McGaha of Wichita Falls, ex-president of the Texas Mid-Continent and now president of the National Stripper Well Association

Two names famous in the discovery of Spindletop are represented here. At the left are the Hamill brothers, Al W., Curt G., and Jim G., who drilled the Lucas gusher. At the right are Mr. and Mrs. Anthony F. G. Lucas of Washington, D. C., daughter-in-law and son of the late Captain Anthony F. Lucas who discovered Spindletop

☆

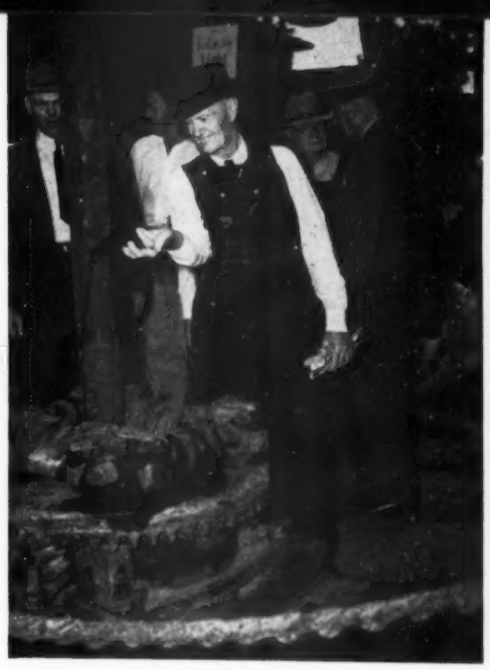
The Lucas gusher monument, built of Texas granite, was dedicated as part of the Spindletop anniversary celebration. It is situated over the hole of the old Lucas discovery. Part of the crowd that attended the ceremonies is shown

The Spindletop anniversary wildcat spudded as part of the Texas Mid-Continent Oil and Gas Association convention was located in the heart of the Beaumont business section. A duplicate of the original rig that drilled the Lucas gusher was assembled, and an old wooden derrick from Spindletop was re-erected on the wildcat location



Two of the pictorial sections of the Spindleto monument showing the four principal activities o the oil producer. At the left, is drilling and at th right, discovery. Panels representing explorati and production are on the other two sides

When Al W. Hamill of Tulsa, driller of the Lucas gusher, got in this 1901 buckboard, he was reminded of the good old days when the horse knew the way. Here he is with Mrs. J. Cooke Wilson of Beaumont, wife of the chairman of the Beaumont convention of the Texas Mid-Continent Oil and Gas Association, preparatory to going to the anniversary wildcat location



(Right) A bottle of oil from the Lucas gusher was used to christen the townlot wildcat that spudded-in the Spindletop anniversary celebration. Here is Al W. Hamill, driller of the Lucas well, pouring the oil on the drill pipe

George Sawtelle of Houston, president of the Kirby Petroleum Company, was elected president of the Texas Mid-Continent Oil and Gas Association at its 22nd annual meeting at Beaumont.

(Right) The most famous crew in history spudded the wildcat drilled in downtown Beaumont as a feature of the Spindletop anniversary celebration. In overalls (from left to right) are George S. Davison of Pittsburgh, former president of the Gulf Refining Company, who came to Beaumont in 1902 for the Guffey Petroleum Company, predecessor of the Gulf; Curt G. Hamill of San Antonio, who helped drill the Lucas gusher; Jim G. Hamill, head of the old Corsicana firm of Hamill Bros., drilling contractors, who held the contract for the Lucas gusher; J. Edgar Pew of Philadelphia, vice-president of the Sun Oil Company, shown here tightening the grip rings on the old rotary, and right, Al W. Hamill of Tulsa, driller of the Lucas gusher. In civilian clothes and smiling broadly is Scott W. Myers of Beaumont, who assembled the old rig, a duplicate of the one that drilled the Lucas well.

Taking the crew to the anniversary wildcat was this old casing wagon drawn by a pair of mules. Shown in overalls are Curt G. Hamill of San Antonio and Jim G. Hamill of Fort Worth, who helped drill the Lucas gusher

A trio of those connected with the oil history of Beaumont talk over old times while seated on the base of the Lucas gusher monument. From left to right they are J. Edgar Pew of Philadelphia, vice-president of the Sun Oil Company, who bought some early Spindletop properties to establish the Sun Oil holdings in Texas; T. J. Donoghue, retired vice-president of The Texas Company, who was a Spindletop pioneer, and Harry C. Wiess of Houston, president of the Humble Oil and Refining Company, member of a pioneer Beaumont family

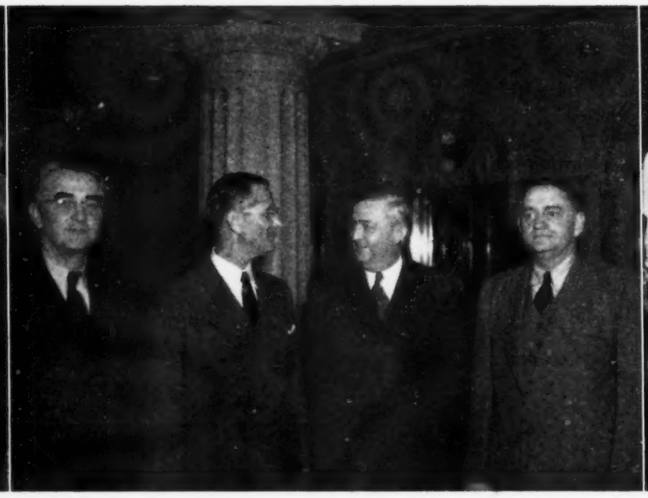
I. P. A. A. Meets in Tulsa

Harry Leonard, Roswell, New Mexico, producer, with Russell B. Brown, general counsel of I.P.A.A.

William H. Wildes, president of Republic Natural Gas Company, Dallas, was elected to the I.P.A.A. Executive Committee

Joe S. Bridwell, Wichita Falls, buys a luncheon ticket

Frank Phillips, chairman of Phillips Petroleum Company, entertained the Independents at his famous Woolaroc Ranch, near Bartlesville, Oklahoma. He is shown on the left, Wirt Franklin, past president of I.P.A.A., now senior director, Office of Petroleum Co-ordinator, District 2, Chicago headquarters, at right



Wirt Franklin; Frank Buttram, Oklahoma City, president of I.P.A.A.; John B. Cowden, Dallas, and Walter L. Goldston, Jr., Houston, Texas

Two Michigan operators: Joe E. Drury, Beaverton and Harold M. McClure, Alma

Congressman William P. Cole, Jr., Maryland, of Cole Committee fame, was speaker at the I.P.A.A. meeting

Charles F. Roeser, Fort Worth, past president of I.P.A.A., and Harold B. Fell, Ardmore, Oklahoma, executive vice-president of I.P.A.A., (taken in Woolaroc lodge)

Two Kansas drilling contractors and producers. Left Leon Derby, McPherson Drilling Company, Wichita and John W. McKnab, Winfield

A Transcontinental Stratoliner — capacity 33 passengers plus mail and express.

AIRLINERS AID NATIONAL DEFENSE

Commercial air lines of America have an important part in National Defense in transporting men and materials long distances at a great saving of time ... mail and express reach destination quickly...and oil is essential to "keep 'em flying." ℂ Hughes Rock Bits

penetrate hard formations to great depths...save time and speed up drilling to reach the oil so necessary in National Defense and Industrial Progress. A Hughes Tailor-Made Rock Bit is the Driller's "air-mail-special-delivery" straight to the oil sands.

Hughes Tool Co. Houston, Texas

Improved Method For Changing Blowout Preventer Rams

PETROLEUM ENGINEER Exclusive Feature

☆ Hydraulic method saves 2 to 3 hours of the time required by mechanical means

by Russell M. Lilly

RUSSELL M. LILLY

took his college work at Texas Christian University, Fort Worth—Employed by M. F. Powers Natural Gasoline Company, Tulsa, Oklahoma, for a period of three years—Later employed by Texas Pacific Coal and Oil Company and by Sinclair Refining Company—Most of his work was as a refinery chemist—Entered the production end of the industry with one of the major companies five years ago—Is now in the drilling department with this company, making his headquarters at Kermit, Texas.

TO facilitate the changing of Cameron type S. D. A. blowout preventer rams, the engineers of a major oil company have designed and developed an improved hydraulic method that permits this changing operation to be accomplished with a speed, ease, and convenience of manipulation heretofore unappoached.

The use of hydraulic pressure to assist in changing S.D.A. preventer rams is a recognized method. It was, in fact, originally developed in part by the manufacturer of the preventer. The method herewith described enlarges upon the original method employed by the preventer manufacturers by augmenting the equipment used.

Aside from the elimination of the manual effort involved in changing rams by the use of hand-operated mechanical jacks and clamps, the points of superiority of the improved hydraulic over previously used methods are as follows:

1. Lower initial cost of equipment.
2. It is very much faster—and safer.
3. Equipment is unitized and portable, being very small, compact, and light.

The material used consists of three 1½-in. by 1-in. short swage nipples, a short piece of high-pressure wire-wrapped steam hose[1] with special short steel couplings, a 4-way valve of suitable type and pressure rating, three 2-in. by 6-in. wooden blocks of varying lengths to press the dressed ram out, and a steel chain and socket arrangement to pull the replacement ram in. All of this equipment is of the heaviest possible character to best withstand drilling rig abuse. Four 1-in. hammer lug unions are positioned in such a manner that the parts may be quickly assembled and dis-assembled.

The equipment is housed in a small metal tool box, fitted to accommodate the various parts. The internal construction of this box is such that there is a specific place for each piece of equipment and, when the lid is closed, each part is *securely locked* in place and cannot be damaged by striking other objects contained therein.

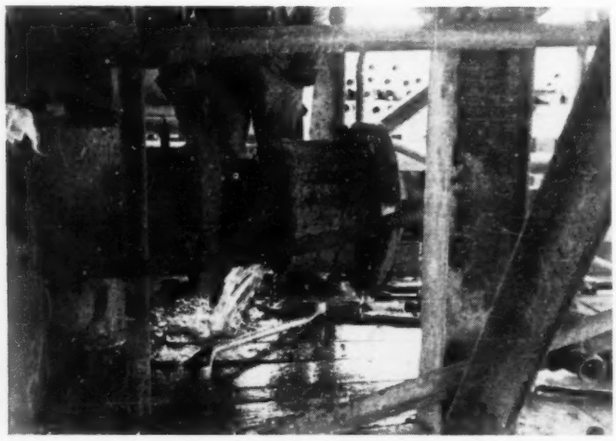
[1]The flexibility of this high-pressure hose permits it to be passed over, around, or between fill-up lines, jet lines, and other cellar equipment that might ordinarily have to be removed to clear the way for the manipulation of mechanical jacks and clamps.

The piping[2] of the opening manifold is altered (Fig. 1) to include a valve between the cylinders which, when closed, separates the cylinders and permits one side to be dismantled while the other, or active, side is used as a

[2]In the past these opening manifold connections were frequently broken off during rig moves. The use of forged steel fittings and double-extra-heavy nipples has completely eliminated breaks due to this type of mishandling.

Control valve hooked up to remove the cylinder. The flexible hose is connected to the side from which the bolts have been removed

As the pressure is applied, the shell or cylinder is shoved off hydraulically



FOUND!

A NEW WAY TO LOWER OPERATING COSTS AND INCREASE EFFICIENCY...

WHEN a major oil company in the Oklahoma City field converted its wells from electric-driven bottom-hole pumps to hydraulic bottom-hole pumps, it became necessary to run an intermediate string. 5½" Smith 80 T & C and Integral Joint Casing were chosen 100% for the job.

Subsequent operation of the new pumping system reveals that the selection of 5½" Smith Casing affords these advantages over a 4" seamless program:

(1) Lower cost than tubing. (2) Tubing not immediately available. (3) Ultimate capacity increased. (4) Permits use of bailer and recovery of reasonable amount of sand. (5) Wire-line wear on production strings minimized. (6) Permits use of original 2½" tubing instead of new ¾" tubing.

Although much of our effort is now given to defense production, A. O. Smith research on casing continues—continues striving to make a fine casing even better. A. O. Smith Corporation, Milwaukee, Wis. Offices at New York, Pittsburgh, Chicago, Tulsa, Dallas, Shreveport, Houston, Corpus Christi, Midland, Los Angeles, Seattle.

A MAJOR producer used an intermediate string of 5½" Smith Casing in this and other Oklahoma City wells to lower pumping and maintenance costs and increase pumping efficiency. In this new application the Smith Casing supports its own weight, as well as the hydraulic bottom-hole pump and the column of oil between the intermediate string and the already installed 2½" tubing. Higher joint efficiency, lighter weight, and lower cost were among the factors that prompted the selection of Smith Casing.

DID YOU KNOW?

- That A. O. Smith Corporation—a major supplier of Casing, Line Pipe, and Pressure Vessels for the petroleum industry—was founded at Milwaukee in 1874... *fifteen years after Col. Drake drilled the first oil well at Titusville, Pa.*
- That today, the vast 140-acre plants of A. O. Smith Corporation engage the services of some 7,000 *skilled employees.*
- That, directly and indirectly, A. O. Smith activities provide a consumer public of 60,000 individuals, whose automobiles require *10 million gallons of gasoline and 100,000 gallons of oil annually.*

A.O.SMITH CORPORATION

Milwaukee, Wisconsin

MANUFACTURERS OF ELECTRIC-WELDED

Casing

Pressure Vessels • Line Pipe

The shell or cylinder has been removed. The men are ready to remove the dismantled ram assembly in preparation for installing the replacement

The replacement ram is being dressed, which includes the placing of the large and small piston rubbers and followers on the ram

super-powerful hydraulic press to perform the changing operation.

The movement of the active cylinder is controlled by the 4-way valve,[3] the manipulation of which permits the press to be started, stopped, or reversed, *instantly and at will.*

The changing operation is quite simple and is performed essentially as follows: The valve in the opening manifold is closed. The bolts are removed from one cylinder and the control valve is connected thereto. The valve is manipulated so as to permit fluid to enter this dismantled cylinder, shoving cylinder and head off as a single unit. The valve is now unioned to the active side as in Fig. 2. Wooden[4] spacer blocks of various lengths are placed between the rams and the control valve manipulated as necessary to shove the dismantled ram from the bore. While this ram is being stripped, the replacement ram is picked up, aligned, and drawn into the preventer bore by the simplified draw chain and socket arrangement as shown in Fig. 3. It is then dressed and the cylinder and head picked up, aligned, and drawn to position in the same manner.

The control valve is now moved to the *re-assembled* side and the operation enters the second phase, the routine of which is exactly as described above.

Careful time tests conducted by the engineering department of the company show that the proper application of hydraulic pressure, as provided by this equipment, reduces the previous average changing time of between three and four hours by mechanical methods to approximately 1½ to 2 hours (this refers to "cellar changes" which require appreciably longer than

[3]The 4-way hydraulic control valve must be of a type that will permit a positive shut-off in mid-position.

[4]Wooden blocks are used because, if accidentally dropped into the well, they will float on top of the drilling fluid and can be removed from the hole by filling it up.

Detailed Procedure for Changing Rams

The usual drilling crew of five men should be divided into three sections: one man as catline operator, two men removing and replacing bolts, and two men serving as valve operator and helper, respectively. With this setup, the operating procedure should be in accordance with the following general sequence:

Two men should begin removing the bolts from one side of the preventer while the rest of the crew is stripping the blowout preventer of piping and turnbuckles, removing the drilling nipple, installing the 1½-in. by 1-in. swages in their proper positions, closing the 1½-in. plug valve, screwing the 4-way valve on the derrick hose, and otherwise getting ready.

The control valve is unioned up to the swage in the cylinder head. The catline operator takes a slight strain on the cylinder head with the catline. The valve operator manipulates the control valve so as to permit water to enter the cylinder, shoving it off. The valve operator breaks the hose connection from the head and, while the men are setting it down and tying onto the ram assembly, he sets up the control valve on the active side as illustrated in Fig. 2.

A slight strain is taken on the ram assembly with the catline and, while his helper holds the proper sized oak block between the rams, the valve operator causes the active cylinder to move back and forth, each time using a longer block, until the ram has been forced out. Three or four passes of the active side will usually remove a ram—requiring about a minute.

The dressed ram is set down so that two men may begin stripping it. The helper will then tie onto the bare ram to be installed and screw two bolts in it to help hold up the chain. While he is doing this, the valve operator will install the draw chain around the hook on the mud line side. This operation is illustrated in Fig. 3. The catline operator lifts replacement ram to the proper height and the helper starts it in the bore and aligns it. If properly aligned it will match the guide holes exactly, as the chain has no tendency to turn the ram while pulling it in. The ram should be pulled slowly at first, care being taken to see that it doesn't get cocked to one side and bind. By successive passes of the active side, each time taking up slack in the chain, the ram should be pulled in sufficiently to permit the guide plug to be installed. By this time the two men will have the removed ram dis-assembled; the small rubber is placed on the ram and shoved into the cylinder with a wrench handle.

The valve operator and his helper will complete the dressing of this ram while the two men begin removing the bolts in the active side. After the ram is completely dressed it is pulled on into the bore as far as it will go. The catline operator lifts the head and cylinder to the proper height and the valve operator and his helper shove it on the handle and align the bolt holes.

The cylinder is pulled over the big rubber and up against the body flange by passing the draw chain around the cylinder head at the packing gland. The valve operator and his helper will then begin replacing the bolts in the re-assembled side, first spacing five or six of them equally around the flange and drawing them tight.

The valve has remained connected to the side now being dismantled. As soon as these bolts have been removed the valve operator will manipulate the control so as to permit water to enter the cylinder and shove it off.

The valve operator now breaks the flexible hose loose from that side entirely and sets up on the re-assembled side. This set-up differs in that the *control valve* is attached to the *cylinder head* and the *hose* is connected to the *permanent piping.* The operation now enters the second phase in which the sequence is exactly as previously described.

Comments:

A small size chain (string-up chain) tied on to the catline is a convenient aid in handling the preventer parts.

In event the ram needs turning to match the guide plug holes, insert a nail bar or wrench handle between the two bolts on the back of the ram and, as the ram is pulled slowly forward, pry in the desired direction. In this manner the holes can *always* be matched with the greatest ease.

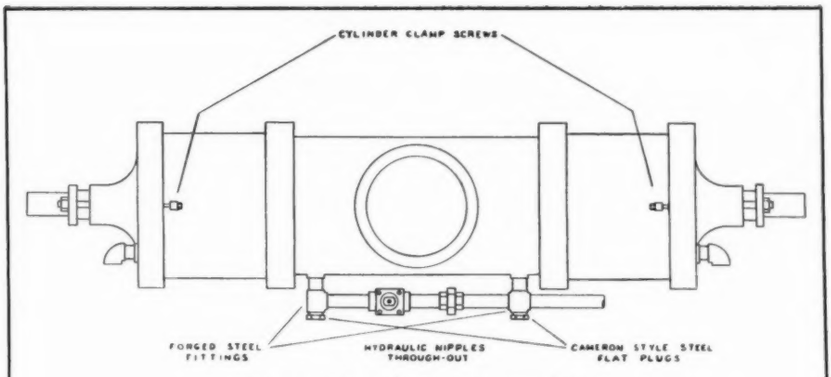


Fig. 1. Altered opening manifold

"floor changes"), *and all the heavy work is accomplished by hydraulic pressure* instead of manually-operated ram jacks and clamps.

Because this equipment is so small, compact, and light it is admirably suited to handling multiple rig installations. The toolpusher can quickly and easily transport it from one drilling rig to another.

The draw chain is a specially purchased $\frac{7}{16}$-in. electric-welded steel loading chain—*of the very best quality.*

With only 300-lb. fluid pressure available, the active cylinder will deliver a force of more than 50,000 lb. to shove a ram from the preventer body. This is far more than can be supplied with conventional jacks, and will remove any ram that is not frozen in place.

With 300-lb. fluid pressure available a force of more than 18,000 lb. can be built up to draw a ram into the preventer body. Because the ram being installed will always have been cleaned up and greased, this force is more than ample.

When changing rams by mechanical methods the cylinder clamp screws shown in Fig. 1 are often seriously damaged or beaten off entirely by sledging. To use the hydraulic method of changing, these clamp screws *must* be repaired and placed in good condition.

Actual Tests

TEST No. 1

Ram changing time—1 hour 50 min.

Sunday, Oct. 6, 1941, Rig. No. A.

Changing rams in Cameron S. D. A. blowout preventer from 4½-in. drill pipe to 5½-in. O. D. casing.

Test started when men walked under the floor with tools at 2:00 p. m. Test ended when the tools were carried back to the rig floor and the blowout preven-

MATERIAL LIST FOR IMPROVED CAMERON RAM CHANGER

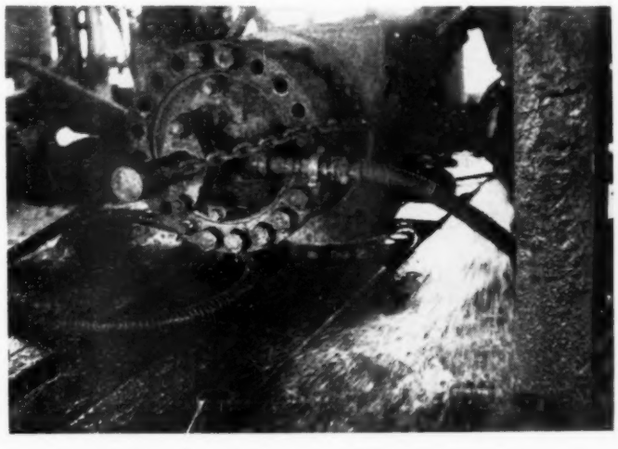
1—1-in. 4-way screwed lubricated plug valve with handle (400-lb. (water) working pressure)	$13.25
1—Box plug lubricant	
4—1-in. cadmium plated (rust-proofed) high-pressure forged steel unions (of the hammer lug type)	3.70
2—1-in. extra heavy seamless steel all-thread nipples	0.15
1—1-in. by 4-in. extra heavy seamless steel nipple	0.10
1—1-in. forged steel ell—3000-lb. (water) working pressure	0.44
3—1½-in. by 1-in. extra heavy seamless steel swages—short type—rust-proofed	3.36
1—1-in. common street ell	.015
1—Heavy harness snap	0.35
1—piece of small size common coil chain—8-in. long	0.10
1—8-in. hinge hasp and loop	0.35
2—12-in. heavy strap hinges	1.50
2—1-in. hose clamps—2-bolt type (clamp parts only—*not* threaded stem)	0.75
1—$\frac{7}{16}$-in. steel chain hook	0.18
18 ft.—$\frac{7}{16}$-in. electric welded **steel loading** chain	6.75
5 or 6 ft. of 1-in wire-wrapped steam hose	(see note)
Total cost of parts	$31.13

Note: Sufficient steam hose is usually available around the rig to serve this purpose.

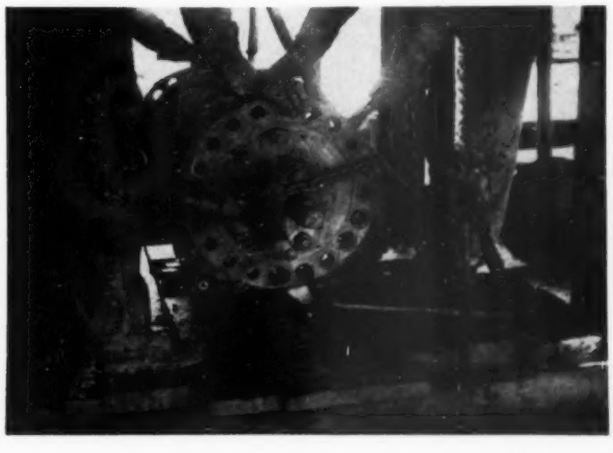
MATERIAL LIST FOR PERMANENT PIPING ON BLOWOUT PREVENTER BODY

3—1½-in. by 3-in. double extra heavy seamless steel nipples	$ 1.15
1—1½-in. by 4-in. double extra heavy seamless steel nipple	0.47
1—1½-in. by 12-in. double extra heavy seamless steel nipple	1.10
1—1½-in. forged steel cross (or 4-way tee)	1.76
1—1-½in. forged steel tee	1.16
1—1½-in. forged steel union (not hammer lug)	1.28
2—1½-in. forged steel flat plugs	
1—1½-in. lubricated plug valve (400-lb. W. O. G.)	8.57
Total cost for permanent piping on blow-out preventer	$15.49

After the replacement ram has been started in the bore, the chain and socket arrangement installed on the active cylinder is used to pull the ram in place



The shell is pulled into position by the chain and socket arrangement



COMPARISON OF DESIGNS

Hydraulic Ram-Changing Manifolds Now in Use

1. Most manifolds now used consist of four valves (2 block valves and 2 relief valves) plus several nipples, tees, ells, etc.
2. Regular valves are subject to occasional replacement because of leakage, broken wheels and bent stems.
3. Flexibility is necessary to compensate for variations in piping between different blowout preventers. This is achieved by compounding a series of ells and nipples into double half swings.
4. Two chains and two single trees constitute the device used to press the rams and shell into place.
5. It has heretofore been necessary to remove the permanent piping completely and screw the manifold fittings directly into the body of the B. O. P. This was unsatisfactory and time-consuming.

Improved Ram-Changing Design

1. The four-way valve replaces the 4 regular valves and many of the connections.
2. The plug valve is far sturdier than regular valves and is not subject to this kind of damage. If kept lubricated and properly adjusted, it will not leak.
3. High-pressure rubber hose provides greater flexibility and a less complicated hook-up. It has a further advantage in that it can be passed over, around or between fill-up lines, jet lines and other cellar piping, eliminating the necessity for their removal. (This is well illustrated in the accompanying photographs.
4. Simplified chain arrangement consists of two chains welded at one end to a thimble or socket, thereby making the assembly a compact one-piece unit, reducing the weight by 60 or 70 pounds.
5. The altered piping is a convenience and saves time, it being necessary to remove only two steel plugs to install the manifold.

ter tested at 3:50 p. m. Elapsed time 1 hour and 50 minutes.

Comments:

This was not a fair test in that, while circulating waiting on orders, the drilling crew had washed down the blowout preventer, removed the ram handwheels, the turnbuckle, and about half the total number of bolts. To counteract this advantage, the flowing of salt and sulphur water over the blowout preventer (due to gas in the Yates) had so corroded and stuck the nuts that the bolts were removed with extreme difficulty.

TEST No. 2

Ram changing time—2 hours 30 min.

Monday, Oct. 7, 1941, Rig No. A.

Changing rams in Cameron S. D. A. blowout preventer from 5½-in. O. D. casing back to 4½-in. drill pipe.

Test started when men walked under the floor with tools at 3:30 a. m. Test ended when tools were carried back to floor at 6:00 a. m.

Comments:

This was a fair test in that there was no advantage due to previous partial dismantling. However, due to the fact that the driller and fireman were busy at the boilers, the rams were changed shorthanded by the derrickman and the two floormen.

TEST No. 3

Ram changing time—1 hour 37 min.

Wednesday, Oct. 16, 1941, Rig No. B.

Changing rams in Cameron S. D. A. blowout preventer from 3½-in. drill pipe to 5½-in. O. D. casing.

Test started when men walked under floor with tools at 11:45 a. m. Test ended at 11:55 when crew stopped to eat dinner. Men walked back under floor at 12:15 p. m. Test ended when tools were carried back to floor and blowout preventer was tested at 1:42 p. m.

Comments:

This was a fair test in every respect. While circulating in preparation for obtaining hole sample, drill crew washed down blowout preventer and removed turnbuckles but proceeded no further with dismantling. The bolts, being of heavy thread and not corroded to any extent, were removed with ease.

About 5 minutes were lost refitting blowout preventer piping, which had become sprung in some manner. These 5 minutes were included in the changing time.

TEST No. 4

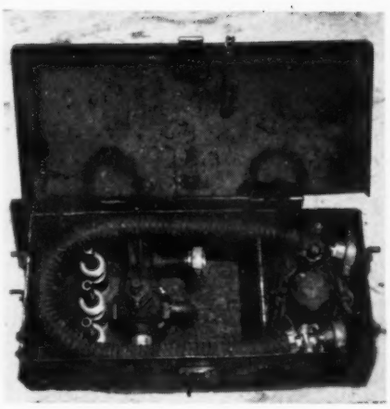
Ram changing time—1 hour 40 min. (est.)

Thursday, Oct. 17, 1941, Rig No. B.

Changing rams in Cameron S. D. A. blowout preventer from 5½-in. O. D. casing back to 3½-in. drill pipe.

Timing started when men walked under floor at 12:35 a. m. Test ended when tools were carried to tool platform at 1:29 a. m.

Comments:



The kit is fitted in a steel case

This test was incomplete. While waiting on cement, one crew had removed two-thirds of the bolts on one side of the blowout preventer and all the bolts and the shell on the other side. The ram assembly was still in place. The crews changed at midnight and the operation was completed and tested in 54 minutes. As nearly as can be estimated, this test took about 1 hour and 40 minutes.

CONCLUSIONS FROM TESTS

Average ram changing time by mechanical means is figured at about 4 hours. It frequently takes less time—and quite frequently more time.

While making these tests the crews were working under pressure. That is, they knew that the operation was being timed. It is possible that they worked at a faster rate than they would ordinarily. Nevertheless, it seems probable that the ram changing operation can be completed in two hours—consistently and with ease.

☆☆☆

Fig. 2. Control valve set-up

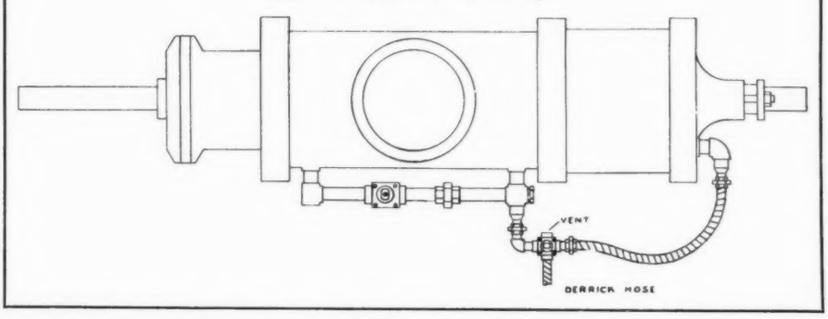
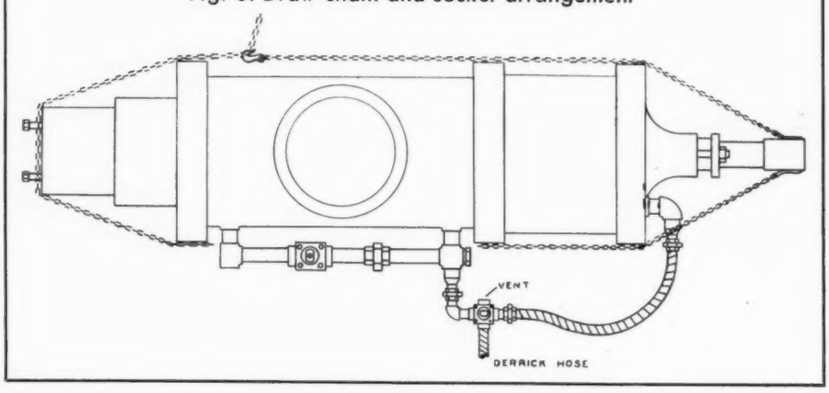


Fig. 3. Draw chain and socket arrangement



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2. Easy Operation
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1. Automatic Lubrication.*
2. Full-Port Lubricant Sealing Grooves.
3. Wedge-Proof cylindrical Super-Surfaced Core.
4. Sealing Grooves on Plug never pass Ports.

1. AUTOMATIC LUBRICATION — Provides a constant lubricant seal. Line pressure automatically forces lubricant from reservoirs to sealing grooves. Eliminates necessity of frequent operation of lubricant screw. Ample downstream (sealing end) lubrication. Reduces friction—valve turns easily. Reduces wear and extends life of valve

2. FULL-PORT SEALING GROOVES — Sealing grooves encircle ports — assures complete uniform seal. Provides a dependable seal against high pressures, liquid or gas. Full-Port Lubrication thoroughly lubricates core—valve operates easily. Reduces washouts. Reduces wear and extends life of valve

3. WEDGE-PROOF SUPER-SURFACED CORE—Cylindrical Core positively cannot wedge—permits easy turning. Perfect fit of core to body conserves lubricant and maintains leakproof seal longer. Lubricant lasts longer...saves time...saves valves. Super-Surfaced core provides extra resistance to abrasives and corrosion agents. Reduces wear—lasts longer

4. SEALING GROOVES ON CORE— Never exposed to fluid. Prevent loss of lubricant into fluid line...insures constant seal. Protects sealing grooves on core from direct cutting action of fluid. Lessens intrusion of abrasives into lubricant sealing grooves...reduces wear on vital sealing surfaces. Prolongs life of valve

* When lubricating a Mission Plug Valve, a portion of the lubricant is forced into reservoirs. Thereafter, the line pressure AUTOMATICALLY feeds this stored lubricant, as needed, into the down-stream seal grooves. So long as lubricant remains in the reservoir a perfect seal is assured.

MISSION MANUFACTURING CO.

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Jack lines from this central power extend over broken territory

Some Aspects of Mechanical Pumping at Comodoro Rivadavia

PETROLEUM ENGINEER Exclusive

☆ **Close attention paid to effect of viscosity on rod stress—Insert type pumps used extensively**

by D. Marcos Seifer

Engineer, Yacimientos Petroliferos Fiscales, Argentina

CONSIDERING that more than 98 percent of the production in the Y.P.F. fields of Comodoro Rivadavia is obtained by means of mechanical pumping, the magnitude of the problems involved is apparent and the importance of the subject of pumping evident.

There are actually about 1600 wells on the pump in the Y.P.F. fields of Comodoro Rivadavia, so that introduction of improvements in production methods, even when they seem elemental in character, have a far-reaching effect when the benefit derived extends over such a considerable number of wells.

The purpose of the present article is to analyze some aspects of the technique of mechanical pumping in the Y.P.F. fields of Comodoro Rivadavia and to propose improvements suggested by such an analysis in the hope that the introduction of improvements will be advantageous from a technical and economical standpoint and at the same time increase safety to the personnel.

Sucker Rod Loads

The movement of the sucker rods and of the oil in the tubing is not uniform and for this reason it determines forces of acceleration that can reach considerable amounts. The acceleration to which the sucker rods are subjected is always a lineal function of the length of the stroke and a quadratic function of the number of strokes. Kemler[1] gives the following formula for the determination of the maximum acceleration:

Maximum acceleration $= 0.00046\ LN^2$ where:

L = length of the stroke, in in.

N = number of strokes per min.

In "Sucker Rods Bulletin No. 128—A. (1135)," published by Oil Well Supply Company, is given a table of

[1] "Design of Sucker Rod Strings," by Emory N. Kemler, *The Petroleum Engineer*, March, 1936.

D. MARCOS SEIFER

upon completion of a course of studies at the National University of La Plata, was graduated as hydraulic and civil engineer in 1935—Entered the service of the Y.P.F. shortly after graduation and is now assistant engineer of production at Comodoro Rivadavia.

PETROLEUM ENGINEER EDITION

BAASH-ROSS News

BAASH-ROSS TOOL COMPANY OF NEW YORK, INC. — NEW YORK

A BULLETIN COVERING NEWS OF EQUIPMENT AND OPERATIONS IN THE PETROLEUM INDUSTRY

OIL INDUSTRY PUTS STAMP OF APPROVAL ON HEXAGONAL KELLYS

Demand Doubles in One Year!

There is probably no other industry today where equipment is purchased more carefully than in the oil industry. In present-day drilling operations, strict cost-service records are kept on each major piece of equipment. All maintenance costs are carefully noted—operating efficiency and total life hours are logged . . . with the result that, after a piece of equipment has been in use a short time, the operator knows *exactly* what that piece of equipment is costing him per hour of service or per foot of hole.

You can't argue with cold turkey evidence like that. So when you find a greater and greater trend among top flight operators toward a certain type of equipment you can bet your bottom dollar that that equipment is doing an outstanding job. . . that it is outperforming anything else they have ever used!

And sales curves on the Baash-Ross Hex Kelly show, definitely, that the big trend today in the oil industry is toward Hex Kellys for ALL drilling work . . . a trend so strong that *in the past year alone* the demand for these Kellys has jumped 2¼ TIMES that of the previous year!

That, plus the fact that *every* year since they were first introduced Baash-Ross Hex Kellys have shown a steadily increasing demand, is conclusive evidence that, on a dollar-for-dollar cost/performance basis, there isn't a kelly in the field today that can stand up against the hex kelly for all-around drilling efficiency.

Here are the kelly features that modern operators want — *and are getting in hex kellys. . .*

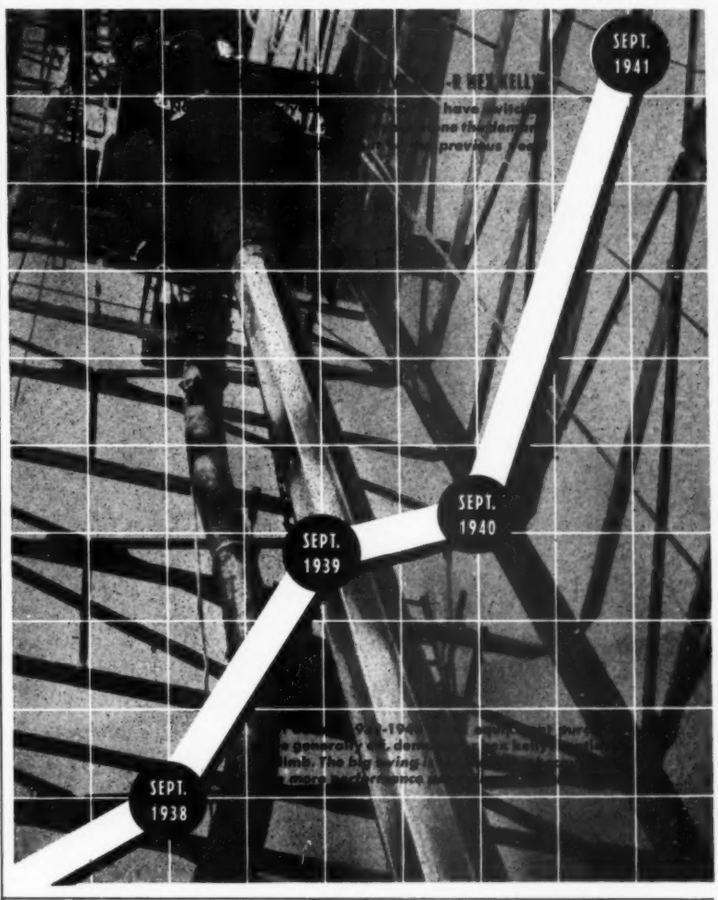
▶ OPERATORS WANT A KELLY THAT STAYS STRAIGHT LONGER! Oil men tell us that one of their greatest difficulties in kelly operation is maintaining straightness. Generally, kellys become bent while being swung back in the rat hole . . . or through improper support while being hauled or racked. In either case, *hex kellys are 23.2%* more resistant to these bending stresses . . . and stay straighter longer under more severe operating conditions than the comparable size of square kelly.*

Once you have tried Hex Kellys, you'll find, as others have, that the longer kelly life, the lower maintenance costs, the greater rigidity provided by this one feature *alone* are features sufficient to justify a complete switch to hex kellys for *all* your drilling requirements.

▶ OPERATORS WANT SMOOTHER OPERATION AT ALL DRILLING SPEEDS! In modern high-speed drilling, balance is an important factor in a kelly. Because hex kellys are *machined* to shape from solid alloy steel stock, they are held to much closer tolerances than possible in the *forged* construction of square kellys. Coupled with their true concentric bore and accurate joint alignment, the result is almost perfect weight distribution . . . and a smoother-running, better-balanced kelly at *all* drilling speeds. Important in today's high rotational speeds, this feature will be even more important as drilling speeds increase.

▶ OPERATORS WANT MAXIMUM FLUID FLOW THROUGH THE DRILL STRING! What good are today's high volume pumps and full hole drill pipe if circulation is choked in the kelly right where the fluid enters the string? In addition to greater strength, *hex kellys have 48%* more circulation area than the comparable size square kelly—a really vital advantage!*

*These figures are based on the widely-used 6" square kelly with 3½" bore vs. the 6⅝" hexagonal kelly with 4½" bore. Because it is the maximum dimension that governs the selection of a kelly size, the 6⅝" hexagonal (across-corner dimension 7¾") is comparable to—in fact, is actually 1/16" *smaller* in its limiting dimension than the 6" square kelly (across-corner dimension 7⅞"). *In other comparable sizes, hex kellys offer proportionate advantages.*



▶ OPERATORS WANT GREATER TORSIONAL STRENGTH! Since the stress of rotating the entire drill string is concentrated in the kelly, its ability to transmit torque without failure is tremendously important. Because of its shape and greater cross-sectional area, *the hexagonal kelly is 28.6%* stronger in torque than the comparable size square kelly.*

▶ OPERATORS WANT MAXIMUM TENSILE STRENGTH! Besides *rotating* the string, the kelly must also *support* it . . . and here again the hex kelly has an edge, being *1.8%* stronger in tension than the comparable size square kelly.*

▶ OPERATORS WANT MAXIMUM ADAPTABILITY! In the widely varying operations of today the hex kelly is far superior to the square for it can be used under *all* drilling conditions—*both regular and pressure work* —without change. With a hex kelly you are ready for *anything—at all times!*

Before you invest in any new kelly equipment, find out how little it costs, how much it pays, to use Baash-Ross Hexagonal Kellys. Your Baash-Ross representative will be glad to go over the matter with you . . . or write us for further information.

ON THE LOOKOUT

ONE WAY OR ANOTHER it looks like the noisy grounding chain that for years has banged along beneath gasoline trucks is about to disappear. At a recent American Chemical Society meeting researchers from a major rubber company described their newest development—a conductive powder that is simply dusted into the tires to prevent static charges from forming. Is more effective—less troublesome—than chains . . . and is noiseless. (No. B-121)

BAASH-ROSS

AND ON THE HEELS of that announcement another company announced their development —a Static Dissipator made of a 30" length of tough *conductive* rubber to hang in place of the chain. Is as effective as chain, lasts longer, and, of course, is noiseless. (No. B-122)

BAASH-ROSS

A UNIQUE TYPE INCLINOMETER for surveying well bores is a recent development. Operates on new electro-chemical principle which eliminates all clockwork and delicate mechanisms. Yet measurements at several different levels can be made on one run. Can be run in and out at speeds of 1000 ft. per minute and only 45 seconds stop is required for each reading, it is claimed, saving rig time. (No. B-123)

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Further information on above items may be obtained by sending your name, address and number of keyed item on a postcard or letterhead.

impulse factors, which, when applied to the static load, show the amount of the dynamic load, the dynamic load being considered as the static load plus the forces of acceleration.

The mathematical equation on which the impulse factor is based, when considering the length and number of strokes, is the following:

$$C = l + \frac{n^2 l}{178570} \quad . \quad . \quad . \quad . \quad (1)$$

C = impulse factor

l = length of the stroke in cm.

n = number of strokes per min.

The dynamic force that supports the sucker rods, then is expressed as:

$$F = (P_1 + P_2)\ \frac{(l + n^2 l)}{178570}$$

P_1 = weight of the rods

P_2 = weight of the oil based on the net section of the piston.

Equation (1), which gives the factor or impulse for length of the stroke and the number of strokes per minute, is shown graphically in Fig. 1.

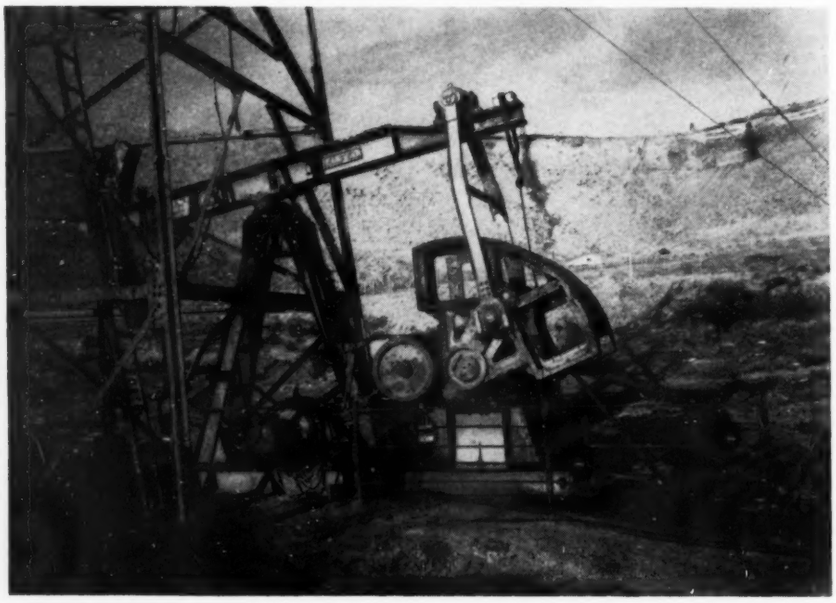
In this graph the length of stroke has been taken as variable and the number of strokes is kept constant with the result that the curves representing the equation are lineal. If the number of strokes for each length of the stroke had been variable, the graphical representation would have corresponded to a second degree parabola.

The dynamic load then being a quadratic function of the number of strokes and a lineal function of the stroke, it appears advisable to adopt a slow, long stroke as a rule of pumping.

Hallan N. Marsh in an article entitled "High Volumetric Efficiency in Oil Well Pumping and Its Practical Results" (A.P.I. Bulletin No. 207, June, 1931) points out the results of some experiments in which is shown the great advantage of working with slow, long strokes. A summation of the results of these experiments is given as follows:

	WELL L-11	
	With 21.8 strokes per minute	*With 10 strokes per minute*
Gross production per day	7.5 cu. meters (47 bbl.)	7. 5 cu. meters (47 bbl.)
Power input	17.85 electric hp.	5. 2 electric hp.
Time off for repairs	0.93 hours per day	0.07 hours per day
Loss of production per year	106.000 cu. meters (667 bbl.)	0.790 cu. meters (50 bbl.)
	WELL V-4	
	With 27 strokes per minute	*With 10 strokes per minute*
Gross production per day	15.00 cu. meters (94 bbl.)	15.00 cu. meters (94 bbl.)
Power input	13.85 hp.	7.2 hp.
Frequency of mechanical failure	0.129 failures per day	0.021 failures per day
Average time employed in repairs	0.865 hours per day	0.222 hours per day
Loss of production	198.50 cu. meters (1250 bbl.)	50.00 cu. meters (314 bbl.)
	WELL V-6	
	With 25.5 strokes per minute	*With 2.77 strokes per minute*
Average gross production per day	2.90 cu. meters (18 bbl.)	2.90 cu. meters (18 bbl.)
Power input	9.13 electric hp.	1.64 electric hp.
	WELL H-A3	
	With 23.3 strokes per minute	*With 6.5 strokes per minute*
Average gross production per day	4.80 cu. meters (30 bbl.)	4.80 cu. meters (30 bbl.)
Power input	16.95 electric hp.	3.75 electric hp.

This unit is pumping two wells, one by means of jack line



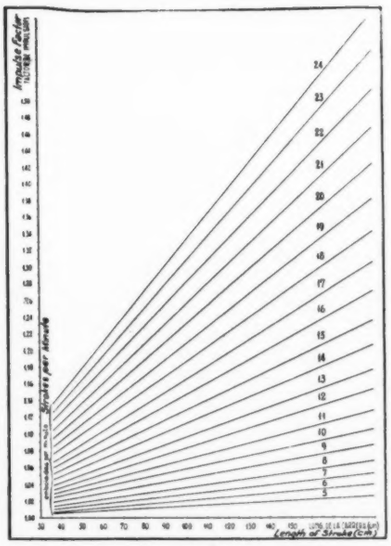


Fig. 1. Impulse factors for mechanical pumping

Viscosity Effect on Rod Stress

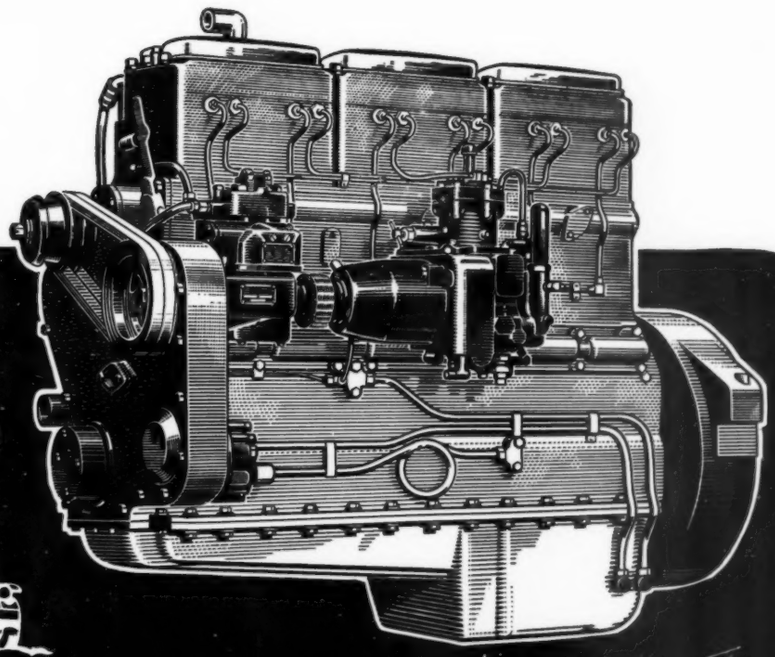
Articles relative to pumping as published by engineers in the United States mention only briefly the influence of the viscosity of the oil on the operation of sucker rods. The majority of the practical tables for determination of this force are calculated by taking water as a pumping fluid. In the case of petroleum of low viscosity, this concept does not introduce appreciable errors but in the case of the fields of Comodoro Rivadavia in which the oil has a high viscosity, the forces calculated by these tables show amounts considerably less than they actually are.

The friction loss of the oil due to the length of the tubing can be calculated mathematically if the curve showing the rate of drop in temperature of the oil from the bottom of the well to the surface is known and a curve showing viscosity thus compiled for the length of the tubing. The determination of the temperature curve, which will vary with the volume of production for each well, does not, however, offer practical application and its mathematical calculation is very questionable.

A practical test has therefore been devised for the purpose of determining directly the loss of load in the tubing as illustrated by well B 293. This test is based on the determination of the maximum force that actuates the piston of the oil-well pump.

This maximum force consists of the sum of the static pressure of the fluid column, of the loss of load for the length of the tubing and lead line and of the force responsible for the acceleration of the liquid.

The static pressure is a function of the depth of the pump and of the



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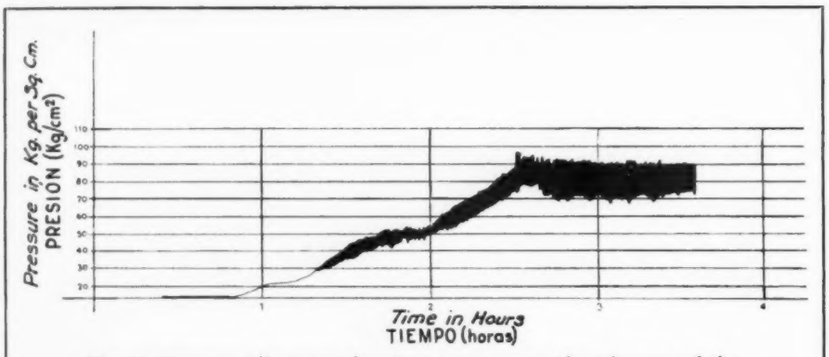


Fig. 2. Pressure diagram showing pressure on the plunger of the pump—well No. B-293

density of the oil, which are known elements; the loss of load in the lead line is obtained directly from the reading of a gauge situated at the mouth of the well; and the original force of the acceleration of the liquid is calculated by applying the impulse factor obtained from Fig. 1.

In this form the loss of load in the tubing results from the difference between the maximum pressure and of the sum of the three amounts enumerated in the preceding paragraph.

The diagram of pressures on the piston of the pump has been obtained by means of Humble equipment, which was lowered simultaneously with the pump in a chamber welded laterally to the tubing close by the pump. This chamber is connected with the tubing by two small orifices.

In Fig. 2 is clearly shown the maximum and minimum pressures at each stroke.

The flattening of the diagram at the 2-hour line coincides with a brief stop at the moment when the oil arrived at the mouth of the well and entered the lead line connection. The pressure at this point corresponds to the amount of the static pressure.

DATA RELATIVE TO THE TEST IN WELL B 293

Depth of well	592 m. (1942 ft.)
Depth of pump	600 m. (1968 ft.)
Production of the well	69 bbl. per day (11 cu. m.)
Diameter of tubing	2 in.
Diameter of sucker rods	¾ in. (with ⅝-in. rod couplings)
Number of strokes per minute	11
Length of the stroke	0.88 m. (30-in.)
Impulse factor	1.06 (from graph showing impulse factors)
Static pressure	52 at. (from diagram)
Maximum pressure	97 at. (from diagram)
Loss of load in the lead line	8 mean at. by gauge at the mouth of the well
Pressure corresponding to the acceleration of the oil	(52 at. × 1.06) — 52 — 3 at.
Loss of load in the tubing	P = 97 at. — (52 + 8 + 3) = 35 at.

It is observed that this amount (67 percent of the static pressure) is of considerable magnitude when it is taken into account that the production of the well is relatively low and the depth of the pump rather shallow.

The losses in the tubing due to friction being an inverse function of the fifth power of the diameter the use of tubing of larger diameter than the nominal diameter of the pump is advisable in order to reduce the forces to which the sucker rods are submitted especially in the case of deep wells.

The record of fishing jobs that occurred in the wells of "El Trebol" confirms this. In 12 wells equipped with 2-in. pumps, 2-in. tubing and ⅝-in. rods, 15 fishing jobs occurred in 6 months or about 125 percent; in 6 wells equipped with 2-in. pumps, 2½-tubing and ⅝-in. rods there were only 3 fishing jobs or about 50 percent.

Insert Type Pump

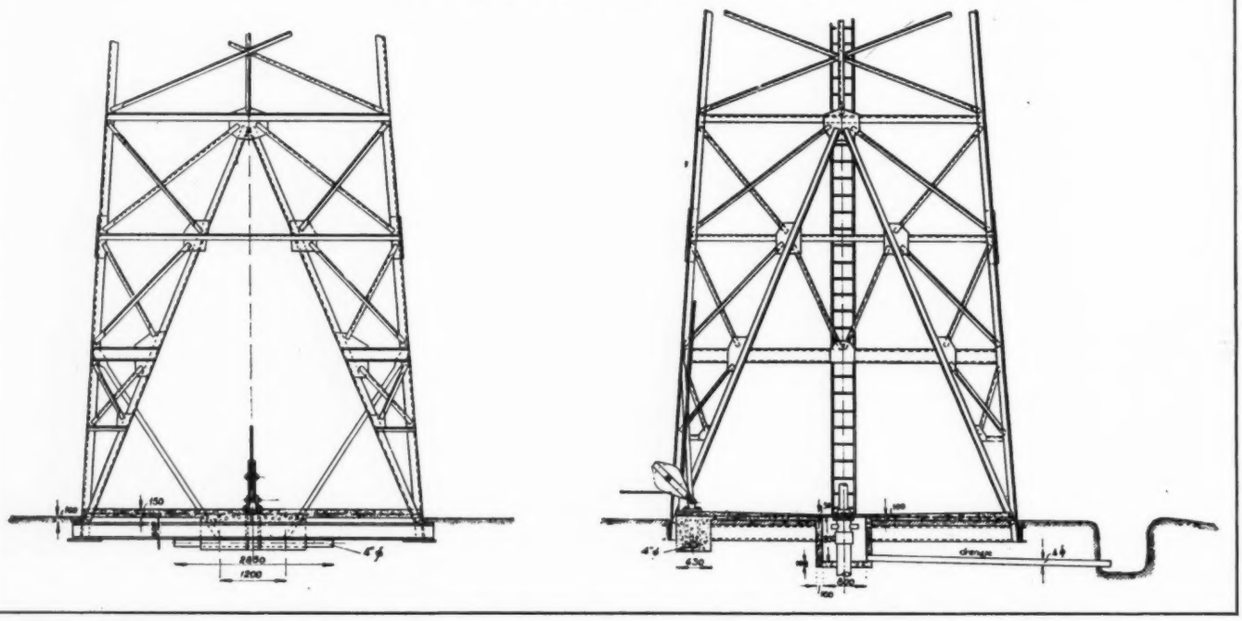
The introduction of this type of pump has solved a number of pumping problems and its use proved of value from the operating and economic standpoints. It is worth noting that in the case of the Escalante sector where many wells whose production by pumping with pumps of the common type encountered difficulties that, after being equipped with pumps of the insert type, they operate normally.

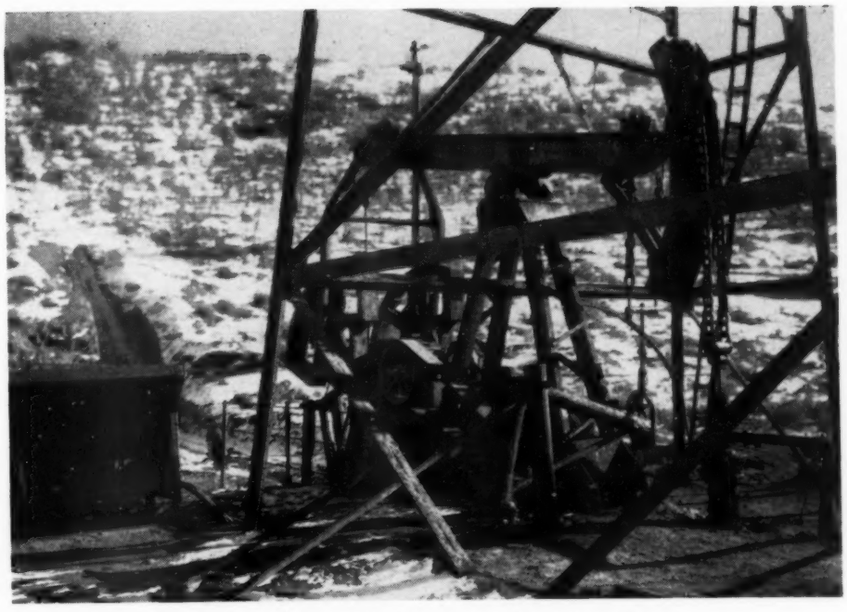
The advantages that this type of pump offers are analyzed in comparison with the pump of the common type.

1. Statistics carried in the sector of Escalante on the time consumed in changing pumps show an average of

(*Continued on page 122-A*)

Fig. 3. Details of concrete floor construction





Three wells are being pumped by this unit

(*Continued from page 120*)

32 hours for the common pump and 8 hours for the insert pump. This reduction in time has the following advantages:

(a) The well is shut down for less time and in consequence the loss of production is less.

(b) The cost of the operation is less.

(c) The efficiency of the hoists is increased now that each one of them can attend to a larger number of wells.

(d) Inasmuch as it is easier to change pumps, changes may be made more frequently and therefore the production of the wells may be maintained.

2. Because of its construction the piston of the common pump must be lowered separately from the body of the pump. The diameter of the piston being only slightly less than the interior diameter of the tubing, it is practically impossible in wells with bad angles or in those in which sand has accumulated in the tubing to get the piston below without its being damaged.

In many wells, especially in Escalante, many pistons have remained out of use for this reason. In order to overcome this difficulty in some wells the piston is run-in while inside the pump and when it has to be pulled the piston is fished out. This procedure is not very safe as the unscrewing of the piston during pulling frequently takes place. With the insert pump such procedure is unnecessary as the entire pump is lowered and pulled with the sucker rods.

3. In common pumps, the binding of the piston due to sand invariably causes excessive abrasion on the piston and the liner and in many cases makes them useless. Furthermore, because of the enormous load that the rods must support as a consequence of the bind, a fishing job usually results. A string of rods that has suffered a break due to an excessive load, on being used again offers the risk of new breaks as the material has suffered permanent deformation that lessens its resistance. A string of rods is preferably removed from service under these conditions.

4. In discussing the influence of friction due to viscosity on the load that the sucker rods must support, the adoption of tubing of larger diameter than the nominal size of the pump is given as a solution. In the case of the insert pump this result is obtained automatically to some extent inasmuch as the difference between the I.D. of the tubing and the diameter of the piston is appreciably greater with the insert pump. This reduction of friction load caused by the viscosity of the oil therefore decreases the total load that the sucker rods must support and reduces the probability of fishing jobs, at the same time requiring less power for the pump.

5. In the wells equipped with insert pumps, tubing operations are reduced to a minimum as it is only necessary to pull the tubing when it is necessary to clean the well. In the wells equipped with common pumps the tubing must be pulled and rerun on each change.

A great number of these operations reduces the life of the tubing and furthermore always incurs the risk of fishing jobs, especially in deep wells.

Improvements at the Wells

The improving of well installations with the object of obtaining greater efficiency of equipment and personnel and at the same time reduce to a minimum the hazard of accidents has been, and still is, the constant endeavor of the engineers. Because of this, engineers in the Comodoro Rivadavia fields have planned to introduce improvements in installations at the wells that, once generally used throughout the field, will result in advantages from the technical and economic standpoint and in increased safety.

Concrete Derrick Floors

The natural earthen floor in the derricks, even when it is well taken care of, does not guarantee the cleanliness adequate for normal work in producing wells. In the winter season the rain and snow cause a muddy condition that slows operations and exposes the personnel to accidents.

Working under these conditions lowers the morale of the workers and is soon reflected in the quality of their work. In the operation of changing pumps it is often necessary to pull tubing full of oil as the the foot valve has remained in the pump; in doing this the petroleum that drains from the tubing is spilled around the wellhead and leaves the floor in bad condition.

A concrete floor in the derrick eliminates this inconvenience and provides the personnel with a clean place to work that increases efficiency by making each task easy and safe.

In Fig. 3 are shown construction details of the concrete floor. A gentle sloping of the floor toward the center has been designed to permit easy runoff of the oil so that it can drain toward the concrete space that encircles the wellhead. The liquid that is caught in the drain is drawn off by a pipe that discharges it into a small waste canal.

Sucker Rod Hanger

The rod hanger for use during the pulling and running-in of rods offers a number of advantages:

1. An appreciable economy in time used in the operations is obtained.
2. The workers can manipulate the rods more easily.
3. The system is simpler, cleaner, and less dangerous.
4. The possibility that the threads may become covered with sand is minimized.
5. The construction of a concrete trough is not required.
6. Inasmuch as the rods are hung up there is no danger that vehicles when arriving at the well will run over them.
7. The risk of bending, which is frequent when the rods are pulled and

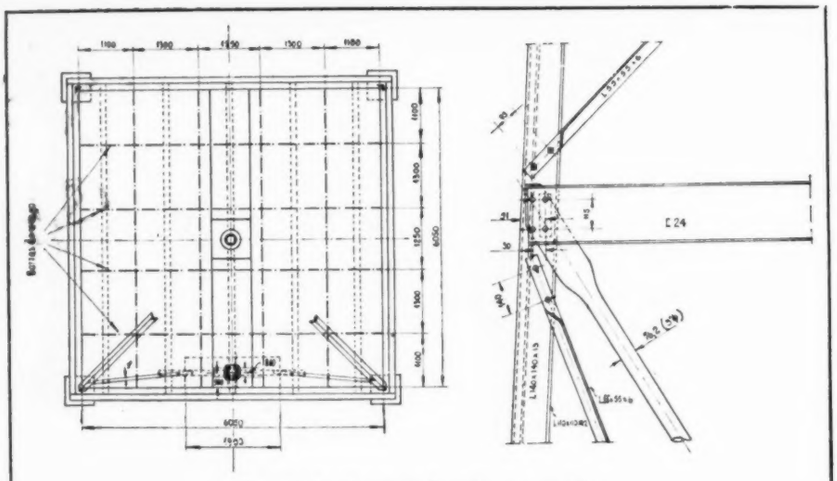


Fig. 4. Anchorage for sheave guide

stacked in double stands outside the derrick without a hanger, is eliminated. The flexibility of the double stand puts considerable strain on the central joint and is one factor contributing to the breakage of the pin. In this respect it is pointed out that in the "El Trebol" area all the fishing for rods that occurred in wells equipped with 7/8-in. rods have been caused by breakage at the pin.

Sheave Guide

In Fig. 4 is shown the anchorage for a sheave guide. The use of the sheave guide in all the operations offered indisputable advantages. In the first place, it permits the installation of the hoist at a convenient distance from the wellhead, thus eliminating all danger of fire. The base of the hoist is horizontal and an anchorage assures its stability. Some instances have been reported of electric hoists having been upset when carrying heavy loads without utilizing the sheave guide. The stress on the crown of the derrick is perfectly vertical and eliminates the probability of its overturning. The cable lasts longer when all possibility of friction at the derrick girts has been eliminated.

Hoist Anchorage

Fig. 5. illustrates the type of hoist anchorage that it is proposed to install in all the producing wells. Its installation is simple and economical and assures working with a sheave guide, a perfect stabilizer for the hoisting equipment.

Central Power Rod Lines

In the fields of Comodoro Rivadavia there are at present 93 central powers pumping 1120 wells. Adding to this figure 96 that are connected to individual units, it makes a total of 1216 jack lines in actual operation.

The care and maintenance of this great number of lines, which suffer frequent breaks because of the considerable strain to which they are submitted, require such a great amount of material and labor that the introduction of improvements tending to diminish the frequency of breaks has a favorable effect on the unit cost of production.

The plan for methodical improvements being brought about in the Comodoro Rivadavia field consists of the modernization of a large quantity of lines that are in bad condition, utilizing better materials, and adopting more regular courses that simplify the installation and decrease the strain imposed on the pull rods.

Improvements in Rod Lines

The lines, if possible, should have a straight course between the well and the central power. The introduction of equipment installed to avoid some irregularities of the terrain always introduces weak points in the line and constitutes elements exposed to wear. It is preferable in the majority of cases to overcome the obstacle by changing elevation of the course. In order to get a reduced and uniform load on the jack-line supports, a horizontal course is not the best as the one that permits the line to operate in equilibrium is more satisfactory. The curve that satisfies this condition is the catenary.

The next procedure is to determine the weight that will rest on each support and correct the height until obtaining a load of 10 to 15 kilograms (22 to 33 lb.). The curve thus reached is approximate to the ideal curve. A horizontal course with a uniform distance between supports imposes loads considerably larger on the supports at the center of the line and thus increases the friction and wear.

The use of ordinary pulleys or rollers lubricated with oil in addition to requiring the constant attention of the personnel causes trouble due to sand that adheres to the oil and thus increases the wear on the line and on the pulley or roller. The ordinary types have been advantageously replaced by paraffined rollers that are prepared by depositing a paste of paraffin and graphite on the grooves made on the surface of the roller where it supports the line.

The use of the paraffined support introduces the following advantages:

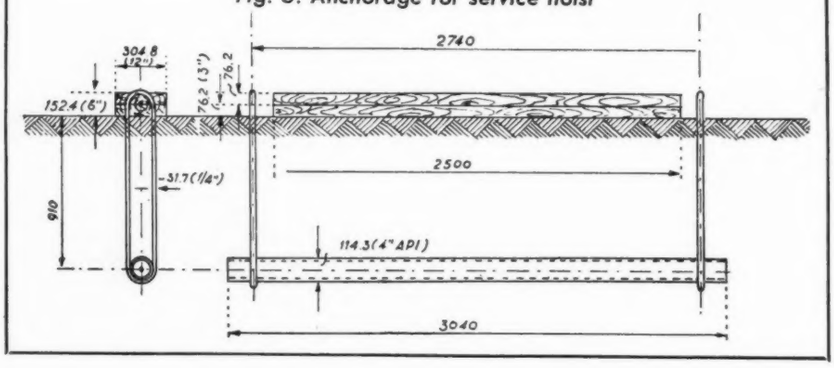
1. Economy in the personnel, as it eliminates the worker in charge of greasing the lines.
2. The inconvenience of sand is removed.
3. Less friction in the jack line.
5. Reduces wear on the rollers.

Heat Treatment

The jack lines are subjected to more severe working conditions than the sucker rods when the well is situated lower than the central pumping power, as the strain in the rods is due to a combination of friction on the line and the component of the weight of the rods. A heat treatment has been tried with good results to improve the texture of the steel of the auxiliary equipment used on the pull lines (clamps, hooks, shafts, etc.). The treatment consists of heating the material to 650° for a period of 3 hours and then letting it cool in air.

——☆☆☆——

Fig. 5. Anchorage for service hoist



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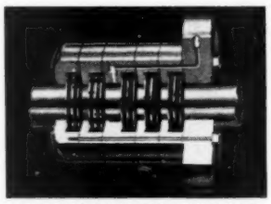

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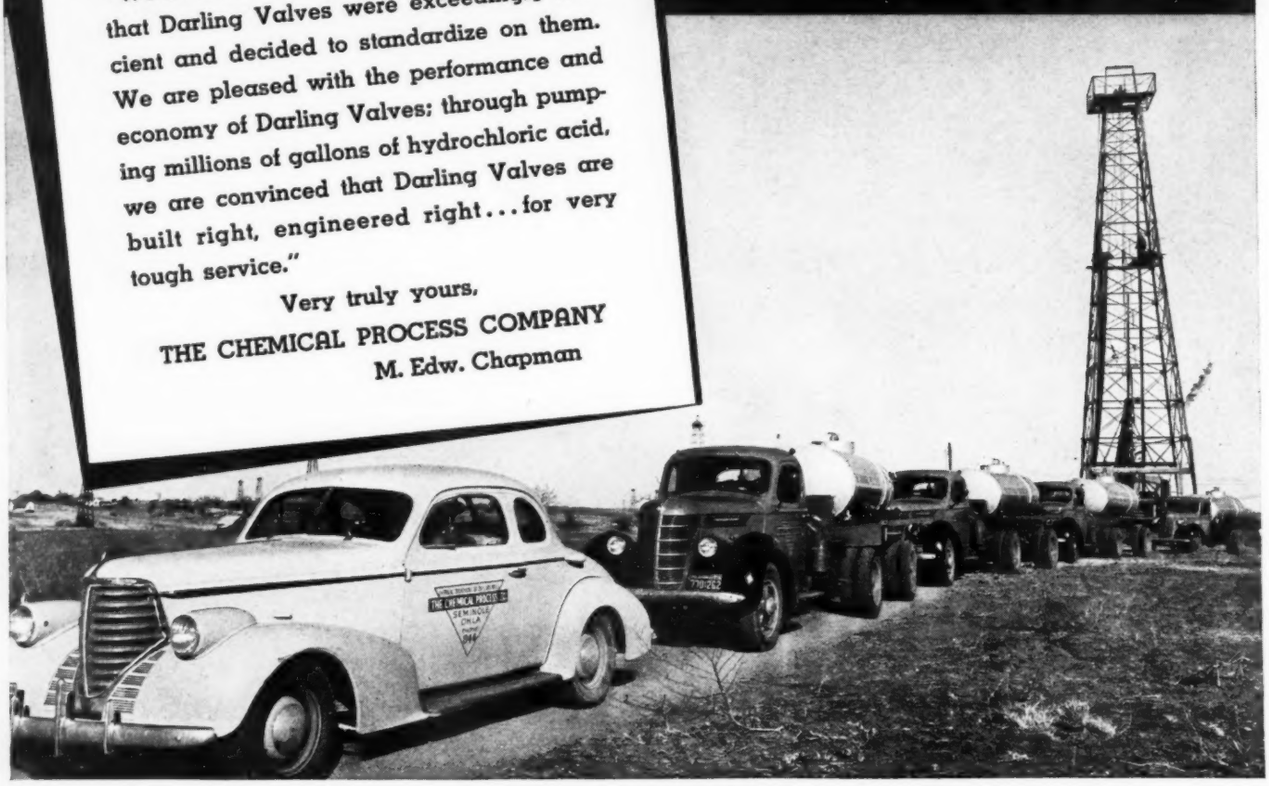

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For the convenience of readers who wish to refer to the tables, each page carries in the upper right corner an index number that classifies the table according to subject matter.

All petroleum engineering literature may be indexed for reference according to the Dewey Decimal System as modified and extended for the petroleum industry by L. C. Uren, professor of petroleum engineering at the University of California. When classified according to these index numbers the material follows in a logical sequence and falls into several natural divisions, as illustrated by the following outline:

Nos. P000-P339—General
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Nos. P500-P599—Production
Nos. P600-P699—Transportation and Storage (includes Pipe Line)
Nos. P700-P799—Refining, including
Nos. P770-P799—Natural Gasoline, which may be classified in a separate division (as shown here) if of special interest to the user

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GRAVITY OF DRY OIL IN OIL-WATER MIXTURE

Gravity of "wet" oil deg. A.P.I.	Percent water in mixture														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
45.0	53.7	54.4	55.1	55.9	56.6	57.4	58.2	59.1	**60.0**	60.9	61.8	62.8	63.8	64.8	65.9
.1	.9	.6	.3	**56.0**	.8	.6	.4	.3	.2	**61.0**	**62.0**	**63.0**	**64.0**	**65.0**	**66.0**
.2	**54.0**	.8	.5	.2	.9	.8	.6	.4	.3	.2	.1	.1	.2	.2	.2
.3	.2	.9	.6	.4	**57.0**	.9	.7	.6	.4	.4	.2	.2	.4	.4	.4
.4	.3	**55.0**	.7	.5	.2	**58.0**	.8	.8	.5	.6	.4	.4	.5	.6	.6
45.5	54.4	55.1	55.8	56.6	57.4	58.2	**59.0**	59.9	60.7	61.7	62.6	63.6	64.6	65.7	66.8
.6	.6	.3	.9	.8	.6	.3	.2	**60.0**	.9	.9	.8	.8	.8	.9	**67.0**
.7	.7	.5	**56.0**	.9	.7	.5	.4	.2	**61.0**	**62.0**	.9	.9	**65.0**	**66.0**	.2
.8	.8	.6	.2	**57.0**	.8	.7	.5	.4	.2	.2	**63.0**	**64.0**	.2	.2	.4
.9	.9	.7	.4	.2	.9	.8	.6	.5	.4	.3	.2	.2	.4	.4	.6
46.0	**55.0**	55.8	**56.5**	57.3	58.1	58.9	59.7	60.6	61.5	62.4	63.4	64.4	65.5	66.6	67.7
.1	.2	.9	.6	.5	.3	**59.0**	.9	.8	.7	.6	.6	.6	.7	.8	.9
.2	.4	**56.0**	.8	.7	.5	.2	**60.0**	.9	.9	.8	.8	.8	.9	**67.0**	**68.0**
.3	.5	.2	.9	.8	.6	.4	.2	**61.0**	**62.0**	**63.0**	**64.0**	**65.0**	**66.0**	.2	.2
.4	.6	.3	**57.0**	.9	.7	.5	.4	.2	.2	.2	.2	.2	.2	.4	.4
46.5	55.7	56.4	57.2	**58.0**	58.8	59.6	60.5	61.4	62.3	63.3	64.3	65.3	66.4	67.5	68.6
.6	.9	.6	.4	.2	.9	.8	.7	.6	.5	.5	.5	.5	.6	.7	.8
.7	**56.0**	.8	.6	.4	**59.0**	**60.0**	.8	.8	.7	.8	.7	.7	.8	.9	**69.0**
.8	.2	.9	.7	.5	.2	.1	.9	.9	.8	.9	.9	.9	.9	**68.0**	.2
.9	.3	**57.0**	.8	.6	.4	.2	**61.0**	**62.0**	**63.0**	**64.0**	**65.0**	**66.0**	**67.0**	.2	.4
47.0	56.4	57.1	57.9	58.7	59.5	60.3	61.2	62.1	63.1	64.1	65.1	66.1	67.2	68.4	69.5
.1	.6	.3	**58.0**	.9	.7	.5	.4	.3	.3	.3	.3	.3	.4	.6	.7
.2	.7	.5	.2	**59.0**	.8	.7	.6	.5	.5	.5	.5	.5	.6	.8	.9
.3	.8	.6	.4	.2	.9	.9	.7	.7	.6	.6	.7	.7	.9	**69.0**	**70.0**
.4	.9	.7	.5	.3	**60.0**	**61.0**	.8	.8	.7	.7	.8	.9	**68.0**	.1	.2
47.5	**57.0**	57.8	58.6	59.4	**60.2**	61.1	**62.0**	62.9	63.8	64.8	65.9	**67.0**	68.1	69.2	70.4
.6	.2	.9	.8	.6	.4	.3	.2	**63.0**	.9	.9	**66.0**	.2	.3	.4	.6
.7	.4	**58.0**	.9	.8	.6	.5	.4	.2	**64.0**	**65.0**	.2	.4	.5	.6	.8
.8	.5	.2	**59.0**	.9	.7	.6	.5	.4	.2	.2	.4	.6	.7	.8	**71.0**
.9	.6	.3	.2	**60.0**	.8	.7	.6	.6	.4	.4	.6	.7	.8	.9	.2
48.0	57.7	58.4	59.2	60.1	60.9	61.8	62.7	63.7	64.6	65.6	66.7	67.8	68.9	70.1	71.3
.1	.8	.6	.4	.3	**61.0**	.9	.9	.9	.8	.8	.9	.9	**69.0**	.3	.5
.2	.9	.8	.6	.5	.2	**62.0**	**63.0**	**64.0**	.9	**66.0**	**67.0**	**68.0**	.2	.5	.7
.3	**58.0**	.9	.7	.6	.4	.2	.2	.2	**65.0**	.2	.2	.2	.4	.7	.9
.4	.2	**59.0**	.8	.7	.5	.4	.4	.3	.2	.4	.4	.4	.6	.9	**72.0**
48.5	58.3	59.1	59.9	60.8	61.6	62.5	63.5	64.4	65.4	66.5	67.5	68.6	69.8	**71.0**	72.3
.6	.5	.3	**60.0**	.9	.8	.7	.7	.6	.6	.7	.7	.8	**70.0**	.2	.5
.7	.6	.5	.2	**61.0**	**62.0**	.9	.8	.8	.8	.8	.9	**69.0**	.2	.4	.7
.8	.7	.6	.4	.2	.2	**63.0**	.9	.9	.9	.9	**68.0**	.2	.4	.6	.9
.9	.8	.7	.5	.4	.4	.2	**64.0**	**65.0**	**66.0**	**67.0**	.2	.4	.6	.8	**73.0**
49.0	**59.0**	59.8	60.6	61.5	62.6	63.5	64.2	65.2	66.2	67.3	68.4	69.5	70.7	71.9	73.2
.1	.2	.9	.7	.7	.7	.6	.4	.4	.4	.5	.6	.7	.9	**72.0**	.4
.2	.4	**60.0**	.8	.9	.8	.7	.6	.6	.6	.7	.8	.9	**71.0**	.2	.6
.3	.5	.2	.9	**62.0**	.9	.8	.8	.8	.8	.8	.9	**70.0**	.2	.4	.8
.4	.6	.4	**61.0**	.1	**63.0**	.9	.9	.9	.9	.9	**69.0**	.1	.4	.6	.9
49.5	59.7	60.5	61.3	62.2	63.1	**64.0**	**65.0**	**66.0**	**67.0**	68.1	69.2	70.3	71.5	72.8	74.1
.6	.9	.7	.5	.4	.3	.2	.2	.2	.2	.3	.4	.5	.7	**73.0**	.3
.7	**60.0**	.9	.7	.6	.5	.4	.4	.4	.4	.5	.6	.7	.9	.2	.5
.8	.2	**61.0**	.8	.8	.7	.6	.6	.6	.6	.7	.8	.9	**72.0**	.4	.7
.9	.4	.1	**62.0**	**63.0**	.9	.8	.8	.8	.8	.9	**70.0**	**71.0**	.2	.6	.9

Hazard WIRE LINES for America's Oil Industry

GREEN SIGNIFIES SAFETY

Ever since Erskine Hazard started making wire rope back in 1846, we have devoted our engineering research, field training and experience, and manufacturing facilities to the end that Hazard Wire Ropes shall serve the users at the lowest possible cost. Indeed the majority of the important developments and improvements to wire rope have been Hazard's.

We have watched the oil industry grow —had our part in aiding its development. Ninety-five years is a long time. Ninety-five years of wire rope making is a lot of experience. Hazard engineers apply this accumulated experience to your rope problems. They recommend:—

FOR ROTARY DRILLING—

HAZARD LAY-SET Preformed green strand is more and more becoming the standard rotary drilling line in all fields because it lasts longer—resists whipping—makes possible faster round trips. LAY-SET Preformed handles easier, spools better, *is safer*. And when you use green strand LAY-SET, you know it is made of Improved Plow Steel—the long-life, greater-dollar-value line.

FOR CABLE TOOL DRILLING—

HAZARD NONPARELL has long been preferred by cable tool drillers. This is one of the lines that is backed by nearly a century of wire rope making experience—known to all the "old timers" as well as the younger drillers, tool pushers and superintendents as the line that gets the job done.

★ *The Green Strand Identifies Hazard Wire Ropes Made of Improved Plow Steel*

HAZARD WIRE ROPE DIVISION • *Established 1846* • **WILKES-BARRE, PENNSYLVANIA**
AMERICAN CHAIN & CABLE COMPANY, INC.
Branches or Distributors in All Important Oil Fields

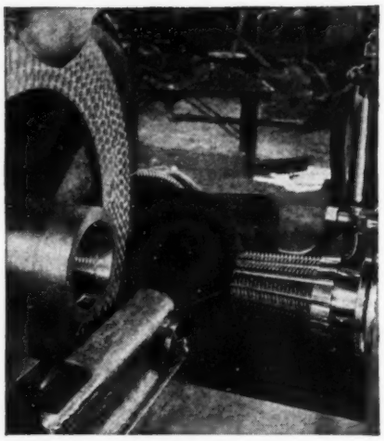
VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH ANNULUS BETWEEN 2-IN. AND 4-IN. TUBING

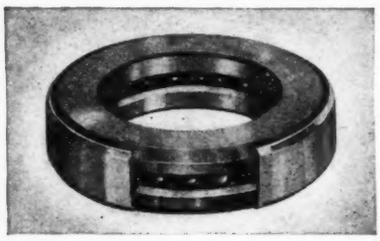
Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	1000	10.8	4.0	2.5	1.8	1.4	1.2	1.0	1.0	0.8
100		21.7	8.6	5.0	3.6	2.9	2.4	2.0	1.9	1.6
150		32.5	12.8	7.5	5.5	4.3	3 6	3.1	2.9	2.4
200		43.4	17.1	10.0	7.3	5.8	4.8	4.1	3.9	3.2
250		54.2	21.4	12.5	9.1	7.2	6.1	5.1	4.8	4.0
300		65.0	26.7	15.0	10.9	8.6	7.2	6.1	5.8	4.8
350		75.9	30.0	17.5	12.8	10.1	8.4	7.1	6.8	5.6
400		86.7	34.2	20.0	14.6	11.5	9.6	8.2	7.7	6.4
50	1250	13 3	5.0	3.4	2.3	1.8	1.5	1.3	1.2	1.0
100		26.6	10 0	6.8	4.5	3.6	3.0	2.5	2.4	2 0
150		39.9	15.1	10 2	6.8	5.4	4.4	3.8	3.6	2.9
200		53.2	21.1	13.6	9.1	7.1	5 9	5.1	4 8	3.9
250		66.4	25.1	17.0	11.3	8.9	7.4	6.3	6.0	4.9
300		79.7	30.1	20.4	13.6	10.7	8.9	7.6	7.2	5.9
350		93 0	35.1	23.8	15.8	12.5	10.3	8.8	8.4	6.9
400		106.3	40.2	27.2	18.1	14.3	11.8	10.1	9.5	7.9
50	1500	16.0	6.0	3.7	2.7	2.1	1.8	1.5	1.3	1.2
100		32.1	12.0	7.4	5.4	4.3	3.5	3 0	2.6	2.3
150		48.1	18.0	11.2	8.1	6.4	5.3	4.5	3 9	3.5
200		64.1	24.0	14.9	10.8	8.5	7.0	6.0	5 3	4.7
250		80.1	30.1	18.6	13.5	10.6	8.8	7.5	6 6	5.8
300		96.2	36.1	22.3	16.2	12.8	10.6	9.0	7.9	7.0
350		112.2	42.1	26.1	18.9	14.9	12.3	10.5	9.2	8.2
400		128.2	48.1	29.8	21.6	17.0	14.1	12.0	10.5	9.3
50	1750	18.6	7.0	4.3	3.1	2.5	2.0	1.7	1.6	1.4
100		37.2	14.0	8.7	6.3	5.0	4.1	3.5	3.3	2.7
150		55.7	21.0	13.0	9.4	7.4	6.1	5.2	4.9	4.1
200		74.3	28.0	17.3	12.6	9.9	8.2	7.0	6.6	5.4
250		92.9	35.0	21.7	15.7	12.4	10.2	8.7	8.2	6.8
300		111.5	42.0	26.0	18.9	14.9	12.3	10.5	9.9	8.1
350		130.1	49.0	30.3	22.0	17.3	14.3	12.2	11.5	9.5
400		148.6	56.0	34.7	25.2	19.8	16.3	14.0	13.2	10.8
50	2000	21.2	8.0	4.9	3.6	2.8	2.3	2.0	1.8	1.5
100		42.5	16.0	9.9	7.2	5.6	4.7	4.0	3.5	3.1
150		63.7	24.0	14.8	10.8	8.5	7.0	5.9	5.3	4.6
200		84.9	32.0	19.8	14.3	11.3	9.3	7.9	7.1	6.1
250		106.1	40.0	24.7	17.9	14.1	11.6	9.9	8.8	7.7
300		127.4	48.0	29.7	21.5	16.9	14.0	11.9	10.6	9.2
350		148.6	56.0	34.6	25.1	19.7	16.3	13.9	12.4	10 8
400		169.8	64.0	39.6	28.7	22.6	18.6	15.9	14.1	12.3
50	2250	23.9	9.0	5.6	4.0	3.2	2.6	2.2	2.1	1.7
100		47.7	18.0	11.1	8.1	6.3	5.2	4.4	4.2	3.4
150		71.6	27.0	16.7	12.1	9.5	7.8	6.7	6.3	5.2
200		95.5	36.0	22.2	16.1	12.7	10.4	8.9	8.4	6.9
250		119.4	44.9	27.8	20.1	15.8	13.1	11.1	10.5	8.6
300		143.2	53.9	33.3	24.2	19.0	15.7	13.3	12.6	10.3
350		167.1	62.9	38.9	28.2	22.2	18.3	15.6	14.7	12.0
400		191.0	71.9	44.4	32.2	25.3	20.9	17.8	16.8	13.8
50	2500	26.5	10.0	6.2	4.5	3.5	2.9	2.5	2.3	1.9
100		53.0	20.0	12.3	8.9	7.0	5.8	4.9	4.7	3.8
150		79.6	29.9	18.5	13.4	10.5	8.7	7.4	7.0	5.7
200		106.1	39.9	24.7	17.9	14.0	11.6	9.9	9.3	7.6
250		132.6	49.9	30.8	22.3	17.6	14.5	12.3	11.6	9.5
300		159.1	59.9	37.0	26.8	21.1	17.4	14.8	14.0	11.4
350		185.6	69.9	43.2	31.3	24.6	20.3	17.3	16.3	13.3
400		212.1	79.8	49.3	35.8	28.1	23.1	19.7	18.6	15.2

[1]Solution of gas and condensation under pressure are not considered; hence the values are maxima.
[2]Gas volumes entering into velocity calculations are based on tubinghead pressure; atmospheric pressure is assumed to be 15 lb. per sq. in. in calculating the number of atmospheres.

IN THE NEWS
WITH BANTAM BEARINGS

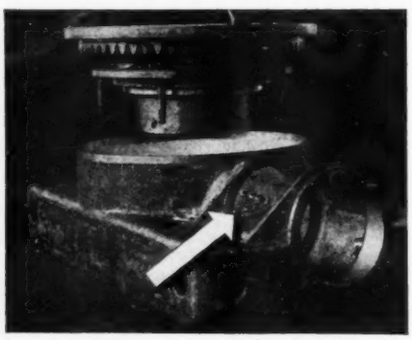
WORLD'S LARGEST POWER SHOVEL, built by The Marion Steam Shovel Company, is provided with a dipper having capacity of 35 cubic yards. Unit shown is in coal stripping service at Tecumseh Coal Corporation. Hoist motor extension shaft of this giant shovel turns on Bantam Radial Roller Bearings measuring 15.25" O.D., having self-aligning features that simplify assembly.



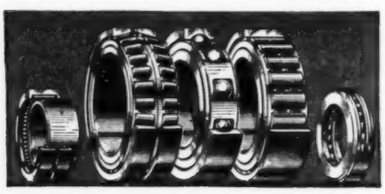


THRUST LOADS UP TO 40,000 POUNDS are carried by Bantam Ball Thrust Bearings, measuring 16" O.D., in this heavy-duty milling machine built by Smalley-General Company. Loads occur in the air cylinder actuating the chuck that holds the work, and are transmitted to the main spindle by a draw pipe. With the Bantam Bearings, the spindle is driven at 50 to 60 R.P.M. by a 5 HP motor—without the bearings 20 HP would be needed. Bantam Bearings have been used on these machines for periods as long as 15 years—without a single case of bearing failure.

A NEW UNDERSEA CRAFT joins the nation's expanding fleet as the Triton is launched at the Portsmouth Navy Yard. Many of America's submarines are equipped with special bearings built by Bantam for this exacting service—bearings of K-Monel metal, for example, that resist the corrosive action of salt air and water.



THE SEARCH FOR OIL goes deeper into the earth, subjecting drilling equipment to heavier loads and severer service. Typical of the equipment designed to meet today's needs is American Well & Prospecting Company's 17½-inch "Gumbo Buster," shown ready for assembly. Rotary table turns on specially designed Bantam Ball Thrust Bearing.



BANTAM MAKES EVERY MAJOR TYPE of anti-friction bearing—straight roller, tapered roller, needle, and ball. Newest addition to Bantam's comprehensive line is the compact, high-capacity Quill Bearing, designed for easy installation, long life, and thorough lubrication. For information on any type of anti-friction bearing—for unbiased counsel on the selection of bearings, TURN TO BANTAM.

BANTAM BEARINGS

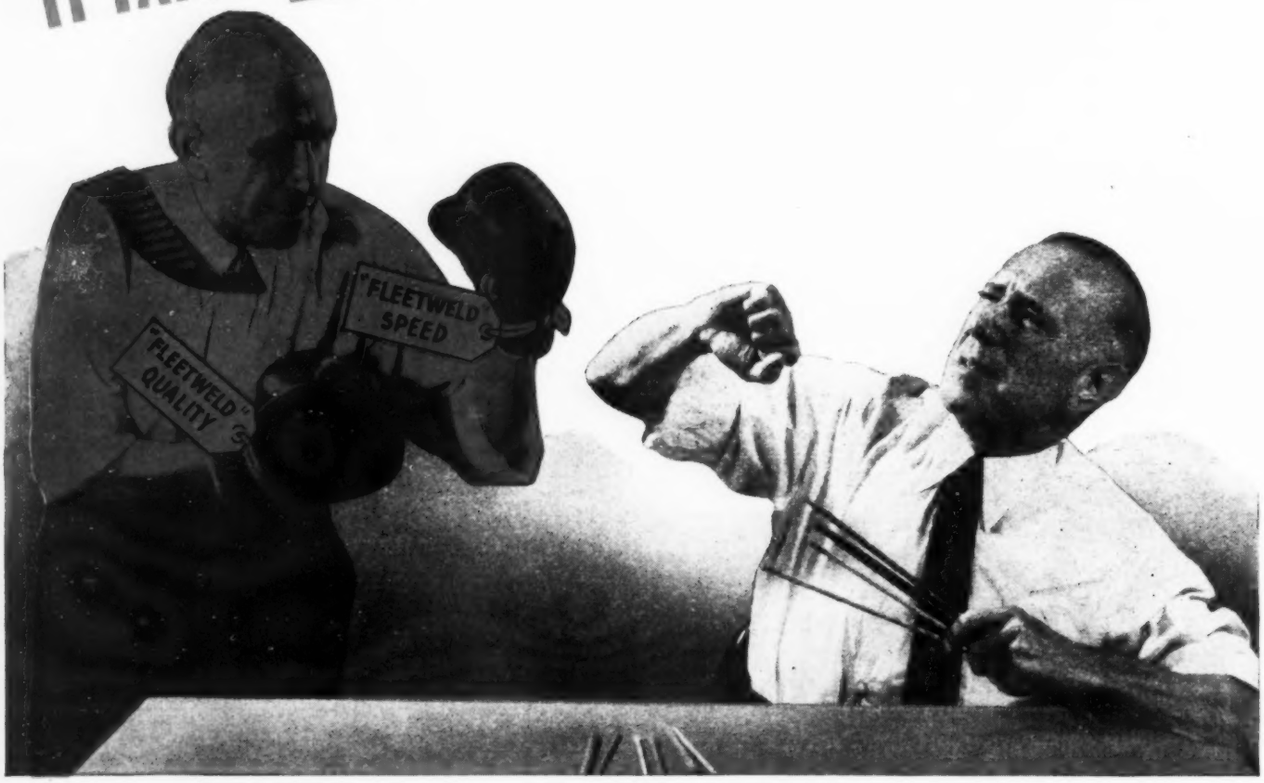
STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

GRAVITY OF DRY OIL IN OIL-WATER MIXTURE, DEG. A.P.I.

Gravity of "wet" oil deg. A.P.I.	Percent water in mixture														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
50.0	50.5	51.1	51.6	52.2	52.7	53.3	53.9	54.6	55.2	55.9	56.6	57.3	**58.0**	58.8	59.5
.1	.6	.2	.7	.3	.9	.5	54.1	.7	.4	56.1	.8	.5	.2	**59.0**	.7
.2	.7	.3	.8	.4	**53.0**	.6	.2	.8	.5	.2	.9	.6	.3	.1	.8
.3	.8	.4	.9	.5	.1	.7	.3	.9	.6	.3	**57.0**	.7	.4	.2	**60.0**
.4	.9	.5	**52.0**	.6	.2	.8	.4	**55.0**	.7	.4	.1	.8	.5	.3	.1
50.5	**51.0**	51.6	52.1	52.7	53.3	53.9	54.5	55.1	55.8	56.5	57.2	57.9	58.6	59.4	60.2
.6	.2	.8	.3	.9	.5	54.1	.7	.3	**56.0**	.7	.3	58.1	.8	.6	.4
.7	.3	.9	.4	**53.0**	.6	.2	.9	.5	.2	.9	.5	.3	**59.0**	.8	.6
.8	.4	**52.0**	.5	.1	.7	.3	**55.0**	.6	.3	**57.0**	.6	.4	.2	.9	.7
.9	.5	.1	.6	.2	.8	.4	.1	.7	.4	.1	.8	.5	.3	**60.0**	.8
51.0	51.6	52.2	52.7	53.3	53.9	54.5	55.2	55.8	56.5	57.2	57.9	58.6	59.4	60.1	60.9
.1	.7	.3	.8	.4	**54.0**	.6	.3	.9	.6	.3	**58.0**	.8	.6	.3	**61.0**
.2	.8	.4	.9	.5	.1	.7	.4	**56.0**	.7	.4	.1	.9	.7	.4	.2
.3	.9	.5	**53.0**	.6	.2	.8	.5	.1	.8	.5	.2	**59.0**	.8	.5	.4
.4	**52.0**	.6	.1	.7	.3	.9	.6	.2	.9	.6	.4	.1	.9	.6	.5
51.5	52.1	52.7	53.2	53.8	54.4	**55.0**	55.7	56.3	**57.0**	57.7	58.5	59.2	**60.0**	60.7	61.6
.6	.2	.8	.3	.9	.5	.2	.8	.5	.2	.9	.6	.4	.2	.9	.8
.7	.3	.9	.4	**54.0**	.6	.3	.9	.6	.3	**58.0**	.7	.5	.3	**61.0**	.9
.8	.4	**53.0**	.5	.1	.7	.4	**56.0**	.7	.4	.1	.8	.6	.4	.2	**62.0**
.9	.5	.1	.6	.2	.8	.5	.1	.8	.5	.2	.9	.7	.5	.3	.1
52.0	52.6	53.2	53.7	54.3	54.9	55.6	56.2	56.9	57.6	58.3	**59.0**	59.8	60.6	61.4	62.2
.1	.7	.3	.8	.4	**55.0**	.7	.4	**57.0**	.7	.5	.2	**60.0**	.8	.6	.4
.2	.8	.4	.9	.5	.2	.8	.5	.1	.8	.6	.3	.1	.9	.7	.5
.3	.9	.5	**54.0**	.6	.3	.9	.6	.2	.9	.7	.4	.2	**61.0**	.8	.6
.4	**53.0**	.6	.1	.7	.4	**56.0**	.7	.3	**58.0**	.8	.5	.3	.1	.9	.7
52.5	53.1	53.7	54.2	54.8	55.5	56.1	56.8	57.4	58.1	58.9	59.6	60.4	61.2	**62.0**	62.8
.6	.2	.8	.4	**55.0**	.7	.3	**57.0**	.6	.3	**59.0**	.8	.6	.4	.2	**63.0**
.7	.3	.9	.5	.1	.8	.4	.1	.8	.5	.2	**60.0**	.8	.6	.4	.2
.8	.4	**54.0**	.6	.2	.9	.5	.2	.9	.6	.3	.1	.9	.7	.5	.3
.9	.5	.1	.7	.3	**56.0**	.6	.3	**58.0**	.7	.4	.2	**61.0**	.8	.6	.4
53.0	53.6	54.2	54.8	55.5	56.1	56.8	57.5	58.1	58.9	59.6	60.4	61.2	**62.0**	62.8	63.6
.1	.7	.3	.9	.6	.2	.9	.6	.2	**59.0**	.7	.5	.3	.1	.9	.8
.2	.8	.4	**55.0**	.7	.3	**57.0**	.7	.3	.1	.8	.6	.4	.2	**63.0**	.9
.3	.9	.5	.1	.8	.4	.1	.8	.4	.2	.9	.7	.5	.3	.1	**64.0**
.4	**54.0**	.6	.2	.9	.5	.2	.9	.5	.3	**60.0**	.8	.6	.4	.2	.1
53.5	54.1	54.7	55.3	**56.0**	56.5	57.3	**58.0**	58.7	59.4	60.2	**61.0**	61.8	62.6	63.4	64.3
.6	.2	.8	.4	.1	.7	.5	.1	.8	.5	.3	.1	.9	.7	.5	.4
.7	.3	.9	.5	.2	.8	.5	.2	.9	.6	.4	.2	**62.0**	.8	.6	.5
.8	.4	**55.0**	.6	.3	.9	.6	.3	**59.0**	.7	.5	.3	.1	.9	.7	.6
.9	.5	.1	.7	.4	**57.0**	.7	.4	.1	.8	.6	.4	.2	**63.0**	.8	.7
54.0	54.6	55.2	55.8	56.5	57.1	57.8	58.5	59.3	**60.0**	60.8	61.6	62.4	63.2	**64.0**	64.9
.1	.7	.3	.9	.6	.2	.9	.6	.4	.1	.9	.7	.5	.3	.2	**65.0**
.2	.8	.4	**56.0**	.7	.3	**58.0**	.7	.5	.2	**61.0**	.8	.6	.4	.4	.2
.3	.9	.5	.1	.8	.4	.1	.8	.6	.3	.1	.9	.7	.5	.5	.3
.4	**55.0**	.6	.2	.9	.5	.2	.9	.7	.4	.2	**62.0**	.8	.6	.6	.4
54.5	55.1	55.7	56.3	**57.0**	57.6	58.3	**59.0**	59.8	60.5	61.3	62.1	62.9	63.7	64.7	65.5
.6	.2	.8	.4	.1	.7	.4	.1	.9	.6	.4	.2	**63.0**	.8	.8	.6
.7	.3	.9	.5	.2	.8	.5	.2	**60.0**	.7	.5	.3	.1	.9	.9	.7
.8	.4	**56.0**	.6	.3	.9	.6	.3	.1	.8	.6	.4	.2	**64.0**	**65.0**	.8
.9	.5	.1	.7	.4	**58.0**	.7	.4	.2	.9	.7	.5	.3	.1	.1	.9

IT TAKES TWO FISTS TO KEEP HEALTHY



ALTER EGO: Literally, "one's other self"—the still, small voice that questions, inspires and corrects our conscious action.

We've got some welding procedure problems to whip before we get into the Battle for Business a few years hence.

ALTER EGO: You're right—but are we tackling those problems of welding technique with the most capable of welding electrodes?

Maybe that's where we slip, since we use a few pounds of this, then a few pounds of that. So first of all let's find out which electrode is tops and then stick to it.

ALTER EGO: Good reasoning! And with the same simple reasoning, isn't the leader most apt to be the best one? Isn't the one which is emulated by all apt to be the best one? Competition seldom aims at the second best. Isn't "Fleetweld" the one about which they say, "Ours is as good as?"

Yes—and it's a fact, when we use "Fleetweld" we top our schedule in SPEED and we top all others in SOUND WELDS.

ALTER EGO: Then using the same formula—if we *hit* with tops in speed, and *guard* with tops in quality, there is no welding problem that can stand up before *that* attack.

• •

LINCOLN SUGGESTS: There's really no end to the possibilities for cost reduction and product improvement with Welding. You can continually discover new welding applications and ways to use welding to better advantage. Users of "Fleetweld" Electrodes find in them the assurance of highest quality weld metal, lowest cost per pound deposited and 28 other valuable aids in making Progress with Welding. See Page 5 of the "Weldirectory."

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LINCOLN "SHIELD-ARC" WELDING THE LINCOLN ELECTRIC COMPANY Cleveland, Ohio

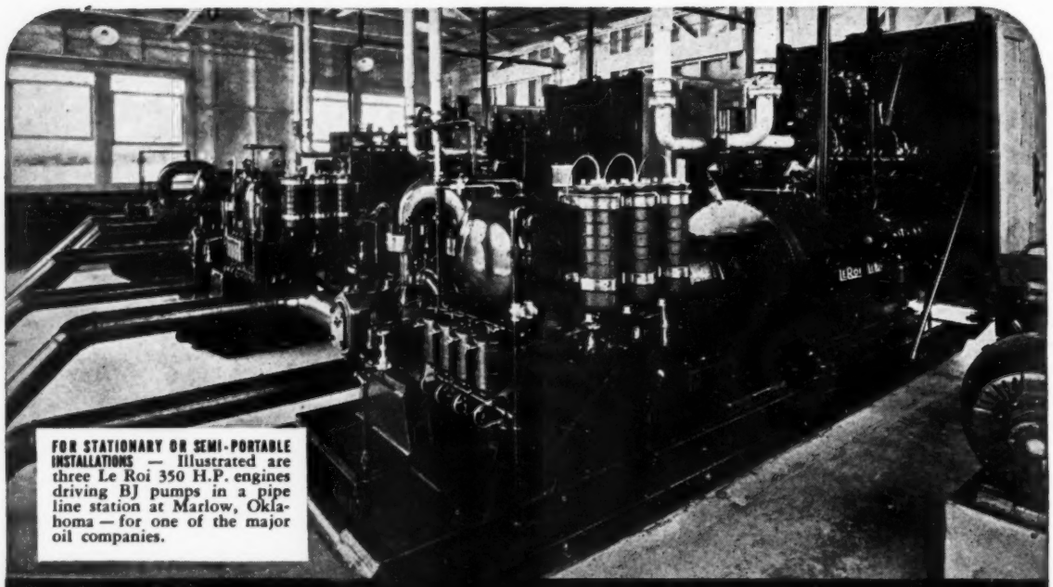
Largest Manufacturers of Arc Welding Equipment in the World

SQUARES OF WHOLE NUMBERS

	0	1	2	3	4	5	6	7	8	9
....	...	1	4	9	16	25	36	49	64	81
10	100	121	144	169	196	225	256	289	324	361
20	400	441	484	529	576	625	676	729	784	841
30	900	961	1,024	1,089	1,156	1,225	1,296	1,369	1,444	1,521
40	1,600	1,681	1,764	1,849	1,936	2,025	2,116	2,209	2,304	2,401
50	2,500	2,601	2,704	2,809	2,916	3,025	3,136	3,249	3,364	3,481
60	3,600	3,721	3,844	3,969	4,096	4,225	4,356	4,489	4,624	4,761
70	4,900	5,041	5,184	5,329	5,476	5,625	5,776	5,929	6,084	6,241
80	6,400	6,561	6,724	6,889	7,056	7,225	7,396	7,569	7,744	7,921
90	8,100	8,281	8,464	8,649	8,836	9,025	9,216	9,409	9,604	9,801
100	10,000	10,201	10,404	10,609	10,816	11,025	11,236	11,449	11,664	11,881
110	12,100	12,321	12,544	12,769	12,996	13,225	13,456	13,689	13,924	14,161
120	14,400	14,641	14,884	15,129	15,376	15,625	15,876	16,129	16,384	16,641
130	16,900	17,161	17,424	17,689	17,956	18,225	18,496	18,769	19,044	19,321
140	19,600	19,881	20,164	20,449	20,736	21,025	21,316	21,609	21,904	22,201
150	22,500	22,801	23,104	23,409	23,716	24,025	24,336	24,649	24,964	25,281
160	25,600	25,921	26,244	26,569	26,896	27,225	27,556	27,889	28,224	28,561
170	28,900	29,241	29,584	29,929	30,276	30,625	30,976	31,329	31,684	32,041
180	32,400	32,761	33,124	33,489	33,856	34,225	34,596	34,969	35,344	35,721
190	36,100	36,481	36,864	37,249	37,636	38,025	38,416	38,809	39,204	39,601
200	40,000	40,401	40,804	41,209	41,616	42,025	42,436	42,849	43,264	43,681
210	44,100	44,521	44,944	45,369	45,796	46,225	46,656	47,089	47,524	47,961
220	48,400	48,841	49,284	49,729	50,176	50,625	5,1076	51,529	51,984	52,441
230	52,900	53,361	53,824	54,289	54,756	55,225	55,696	56,169	56,644	57,121
240	57,600	58,081	58,564	59,049	59,536	60,025	60,516	61,009	61,504	62,001
250	62,500	63,001	63,504	64,009	64,516	65,025	65,536	66,049	66,564	67,081
260	67,600	68,121	68,644	69,169	69,696	70,225	70,756	71,289	71,824	72,361
270	72,900	73,441	73,984	74,529	75,076	75,625	76,176	76,729	77,284	77,841
280	78,400	78,961	79,524	80,089	80,656	81,225	81,796	82,369	82,944	83,521
290	84,100	84,681	85,264	85,849	86,436	87,025	87,616	88,209	88,804	89,401
300	90,000	90,601	91,204	91,809	92,416	93,025	93,936	94,249	94,864	95,481
310	96,100	96,721	97,344	97,969	98,596	99,225	99,856	100,489	101,124	101,761
320	102,400	103,041	103,681	104,329	104,976	105,625	106,276	106,929	107,584	108,241
330	108,900	109,561	110,224	110,889	111,556	112,225	112,896	113,569	114,244	114,291
340	115,600	116,281	116,964	117,649	118,336	119,025	119,716	120,409	121,104	121,801
350	122,500	123,201	123,904	124,609	125,316	126,025	126,736	127,449	128,164	128,881
360	129,600	130,321	131,044	131,769	132,496	133,225	133,956	134,689	135,424	136,161
370	136,900	127,641	138,384	139,129	139,876	140,625	141,376	141,129	142,884	143,641
380	144,400	145,161	145,924	146,689	147,456	148,225	148,996	149,769	150,544	151,321
390	152,100	152,881	153,664	154,449	155,236	156,025	156,816	157,609	158,404	159,201
400	160,000	160,801	161,604	162,409	163,216	164,025	164,836	165,649	166,464	167,281
410	168,100	168,921	169,744	170,569	171,396	172,225	173,056	173,889	174,724	175,561
420	176,400	177,241	178,084	178,929	179,776	180,625	181,476	182,329	183,184	184,041
430	184,900	185,761	186,624	187,489	188,356	189,225	190,969	190,969	192,844	192,721
440	193,600	194,481	195,364	196,249	197,136	198,025	198,916	199,809	200,704	201,601
450	202,500	203,401	204,304	205,209	206,116	207,025	207,936	208,849	209,764	210,681
460	211,600	212,521	213,444	214,369	215,296	216,225	217,156	218,089	219,024	219,961
470	220,900	221,841	222,784	223,729	224,676	225,625	226,576	227,529	228,484	229,441
480	230,400	231,361	232,324	233,289	234,256	235,225	236,196	237,169	238,144	239,121
490	240,100	241,081	242,064	243,049	244,036	245,025	246,016	247,009	248,004	249,001

Example: What is the square of 54?

Solution: In the sixth line (opposite 50) and in the sixth column (under 4) the answer is found to be 2,916.



FOR STATIONARY OR SEMI-PORTABLE INSTALLATIONS — Illustrated are three Le Roi 350 H.P. engines driving BJ pumps in a pipe line station at Marlow, Oklahoma — for one of the major oil companies.

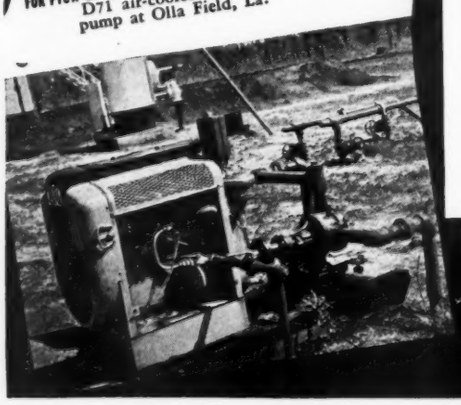
On dependable power for Pipe Line Pumps

you're "low with LE ROI *" all the way — — —*

- low first cost
- low installation cost
- low operating cost
- low maintenance cost

FOR GATHERING SERVICE — *(above)* A LeRoi D201 engine operating a reciprocating pump on the property of a major oil company at Cromwell, Oklahoma.

FOR PICK-UP AND TRANSFER SERVICE — *(below)* A LeRoi D71 air-cooled engine operating a rotary pump at Olla Field, La.



- 4 to 100 H.P. engines for gathering and pick-up pumps.
- 100 to 400 H.P. sizes for main line, standby, or emergency service — capable of handling 12,000 to 35,000 barrels per day.
- Operate on gasoline, natural gas, or butane.
- Engine and pump may be assembled as single unit.
- Compact, stationary unit with portable features — involving minimum expense and loss of time in transferring from one station to another. P-9

Equip with LeRoi — as many leaders do — and enjoy the extra margin of economy, the extra reserve of power that LeRoi engineering gives you. Write, stating size of engine in which you are interested, and we will send bulletins giving complete details.

LE ROI COMPANY • MILWAUKEE, WIS. • TULSA, OKLA.
GENERAL MACHINE & SUPPLY COMPANY
Wichita Falls — Odessa, Texas
SOUTHERN ENGINE & PUMP COMPANY
Houston — Dallas — Kilgore, Texas
WESTERN MACHINERY COMPANY
St. Louis, Missouri • Salem, Illinois

RISE IN FLUID LEVEL, ETC., DUE TO RUNNING 3½-IN. EXTERNAL UPSET TUBING IN WELL FLUID

Diameter of outer string or open hole, in.	Internal diameter of outer string or open hole, in.	Volume[1] contained in outer string or open hole		Volume[1] contained in annular space		Volume[1] in well bore when tubing is in hole (volume in annulus plus volume in tubing)		For every 100 ft. of tubing run in fluid, fluid level will be raised:	
		gal.	bbl.	gal.	bbl.	gal.	bbl.	in annular space when lower end of tubing is closed, ft.-in.	in well bore when lower end of tubing is open, ft.-in.
Casing strings[2]									
6	5.524	124.5	2.964	58.3	1.388	107.6	2.562	113- 6	15- 7
6	5.240	112.0	2.667	45.8	1.090	95.1	2.264	144- 6	17- 8
6⅝	6.135	153.6	3.657	87.4	2.081	136.7	3.255	75- 9	12- 4
6⅝	5.675	131.4	3.129	65.2	1.552	114.5	2.726	101- 6	14- 8
7	6.538	174.4	4.152	108.2	2.576	157.5	3.750	61- 2	10- 8
7	5.920	143.0	3.405	76.8	1.829	126.1	3.002	86- 2	13- 4
7⅝	7.125	207.1	4.931	140.9	3.355	190.2	4.529	47- 0	8-10
7⅝	6.625	179.1	4.624	112.9	2.688	162.2	3.862	58- 8	10- 4
8⅝	8.097	267.5	6.369	201.3	4.793	250.6	5.967	32-11	6- 8
8⅝	7.511	230.2	5.481	164.0	3.905	213.3	5.079	40- 4	7-11
9⅝	9.063	335.1	7.979	268.9	6.403	318.2	7.576	24- 7	5- 3
9⅝	8.535	297.2	7.076	231.0	5.500	280.3	6.674	28- 8	6- 0
10¾	10.192	423.8	10.090	357.6	8.514	406.9	9.688	18- 6	4- 2
10¾	9.760	388.7	9.255	322.5	7.679	371.8	8.852	20- 6	4- 6
11¾	11.150	507.2	12.076	441.0	10.500	490.3	11.674	15- 0	3- 5
11¾	10.772	473.4	11.271	407.2	9.695	456.5	10.869	16- 3	3- 8
13⅜	12.715	659.6	15.705	593.4	14.129	642.7	15.302	11- 2	2- 7
13⅜	12.347	622.0	14.810	555.8	13.233	605.1	14.407	11-11	2- 9
Open hole (bit size)[3]									
5⅝	5.675	131.4	3.129	65.2	1.552	114.5	2.726	101- 6	14- 8
6	6.000	146.9	3.498	80.7	1.921	130.0	3.095	82- 0	12-11
6⅛	6.125	153.1	3.645	86.9	2.069	136.2	3.243	76- 2	12- 4
6½	6.500	172.4	4.105	106.2	2.529	155.5	3.702	62- 4	10-10
6¾	6.750	185.9	4.426	119.7	2.850	169.0	4.024	55- 4	9-11
7	7.000	199.9	4.760	133.7	3.183	183.0	4.357	49- 6	9- 2
7½[4]	7.500	229.5	5.464	163.3	3.888	212.6	5.062	40- 6	7-11
7¾[4]	7.750	245.1	5.836	178.9	4.260	228.2	5.433	37- 0	7- 4
8½[4]	8.500	294.8	7.019	228.6	5.443	277.9	6.617	28-11	6- 1
9¾[4]	9.750	387.9	9.236	321.7	7.660	371.0	8.833	20- 6	4- 6
10⅝	10.625	460.6	10.967	394.4	9.390	443.7	10.564	16- 9	3- 9

The 3½-in. external-upset tubing has a calculated weight of 11.00 lb. per ft. (including a coupling spaced every 20 ft.). The volume displaced by 100 ft. of tubing and 5 couplings: (1) by the steel itself (with lower end of tubing open), 16.809 gal. or 0.40021 bbl.; (2) by the pipe (with lower end of tubing closed), 66.198 gal. or 1.5761 bbl. The volume contained within 100 ft. of the tubing is 49.299 gal. or 1.1738 bbl.

[1]All volume figures are based on 100 ft. of depth; multiply to convert to other depths or lengths. For example, if the depth or length is 5196 ft., multiply by 51.96.

[2]Only maximum and minimum weights of pipe are shown for each casing size.

[3]Variation in diameter of open hole due to caving, etc., is disregarded.

[4]This diameter is an average of the two bit sizes ⅛ in. larger and smaller, respectively.

Table suggested by George B. Rice, Butler & Horne Drilling Co., Dallas, Texas.

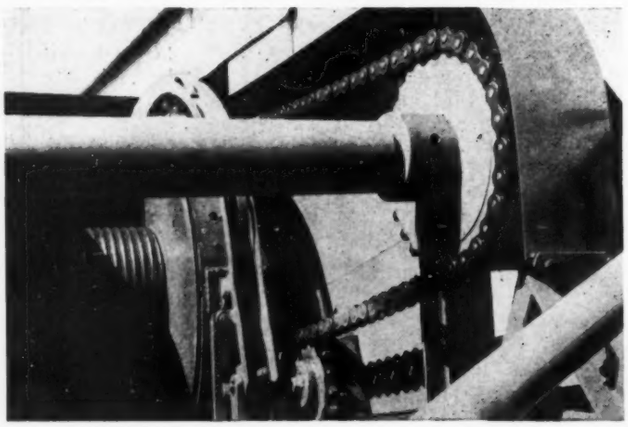
WHITNEY CHAINS

Help the Oil Industry to meet MAINTENANCE DEMANDS

. . . on leading makes of oil-field equipment

Whitney Chains are designed and made to stand overloads without loss of efficiency, without slowdowns or breakdowns . . . to deliver full power to the job 24 hours a day, *every day.* Whitney's solid roller construction withstands higher frequency impacts . . . and the hooked locking pin stands the gaff of chain-whip. So it pays to specify Whitney Chains on all new oil-field equipment, and also for replacements. Whitney engineering, service, and products are no farther away than the nearest representative listed below.

The Whitney Chain Mfg. Co., Hartford, Conn.

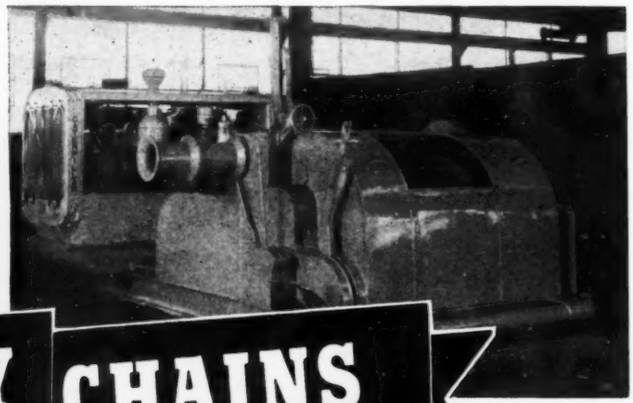


FRANKS MFG. CO. uses Whitney Chains for all drives in their truck-mounted Rotary Drilling Units.

BRIDGEPORT MACHINE CO. standardizes on Whitney in the Double Chain Reducers of all Pumping Units.

TULSA WINCH MFG. CO. uses Whitney Chain Drives on this portable truck-mounted winch.

AMERICAN WELL & PROSPECTING COMPANY's "Gumbo Buster" Draw Works is 100% Whitney-driven.



WHITNEY CHAINS

Mid-Continent Sales and Service

Bull-Stewart Equipment Co., 3219 E. Grand Ave., Dallas, Texas
Brance-Krachy Co. Inc., 4411 Navigation Blvd., Houston, Texas
Gulf States Tractor & Equipment Co., 222 No. Market St., Shreveport, La
Weiss Chain & Transmission Co., 224 East Third St., Tulsa, Oklahoma
A. D. Guggenheim Co., 227 West 7th St., Amarillo, Texas
Warford Distributing Co., 319 So. Topeka Ave., Wichita, Kansas
Prager, Inc., 472 Howard Ave., New Orleans, La.
Oil Field Ignition Parts Co., 325 N. W. Second St., Okla. City, Okla.

Mid-Continent Branch Office

The Whitney Chain & Mfg. Co.
902 Allen Bldg.
Dallas
Texas

West Coast

Engineering Products Co.
747 Warehouse St.
Los Angeles
California

STATIC PRESSURES, LB. PER SQ. IN. ABS., CORRESPONDING TO L-10 CHART READINGS

L-10 Chart Reading, P_L	Range of static pressure element, lb. per sq. in. (R_S)										
	50	100	250	500	1000	1500	2000	2500	3000	4000	5000
1.0	0.500	1.000	2.500	5.00	10.00	15.00	20.00	25.00	30.00	40.00	50.0
1.5	1.125	2.250	5.625	11.25	22.50	33.75	45.00	56.25	67.50	90 00	112.5
2.0	2 000	4.000	10.00	20.00	40.00	60.00	80.00	100.0	120.0	160.0	200.0
2.5	3.125	6.25	15.63	31.25	62.50	93.75	125.0	156.3	187.5	250.0	312.5
3.0	4.500	9.000	22.50	45.00	90.00	135.0	180.0	225.0	270.0	360.0	450.0
.1	4.805	9.160	24.03	48.05	96.10	144.2	192.2	240.3	288.3	384.4	480.5
.2	5.120	10.24	25.60	51.20	102.4	153.6	204.8	256.0	307.2	409.6	512.0
.3	5.445	10.89	27.23	54.45	108.9	163.4	217.8	272.3	326.7	435.6	544.5
.4	5.780	11.56	28.90	57.80	115.6	173.4	231.2	289.0	346.8	462.4	578.0
3.5	6.125	12.25	30.63	61.25	122.5	183.8	245.0	306.3	367.5	490.0	612.5
.6	6.480	12.96	32.40	64.80	129.6	194.4	259.2	324.0	388.8	518.4	648.0
.7	6.845	13.69	34.23	68.45	136.9	205.4	273.8	342.3	410.7	547.6	684.5
.8	7.220	14.44	36.10	72.20	144.4	216.6	288.8	361.0	433.2	577.6	722.0
.9	7.605	15.21	38.03	76.05	152.1	228.2	304.2	380.3	456.3	608.4	760.5
4.0	8.000	16.00	40.00	80.00	160.0	240.0	320.0	400.0	480.0	640.0	800.0
.1	8.405	16.81	42.03	84.05	168.1	252.2	336.2	420.3	504.3	672.4	840.5
.2	8.820	17.64	44.10	88.20	176.4	264.6	352.8	441.0	592.2	705.6	882.0
.3	9.245	18.49	46.20	92.45	184.9	277.4	369.8	462.3	554.7	739.6	924.5
.4	9.680	19.36	48.40	96.80	193.6	290.4	387.2	484.0	580.8	774.4	968.0
4.5	10.13	20.25	50.63	101.3	202.5	303.8	405.0	506.3	607.5	810.0	1013.
.6	10.58	21.16	52.90	105.8	211.6	317.4	423.2	529.0	634.8	846.4	1058.
.7	11.05	22.19	55.23	110.5	221.9	331.4	441.8	552.3	662.7	883.6	1105.
.8	11.52	23.04	57.60	115.2	230.4	345.6	460.8	576.0	691.2	921.6	1152.
.9	12.01	24.01	60.03	120.1	240.1	360.2	480.2	600.3	720.3	960.4	1201.
5.0	12.50	25.00	62.50	125.0	250.0	375.0	500.0	625.0	750.0	1000.	1250.
.1	13.01	26.01	65.03	130.1	260.1	390.2	520.2	650.3	780.3	1040.	1301.
.2	13.52	27.04	67.60	135.2	270.4	405.6	540.8	676.0	811.2	1082.	1352.
.3	14.05	28.09	70.23	140.5	280.9	421.4	561.8	702.3	842.7	1124.	1405.
.4	14.58	29.16	72.90	145.8	291.6	437.4	583.2	729.0	874.8	1166.	1458.
5.5	15.13	30.25	75.63	151.3	302.5	453.8	605.0	756.3	907.5	1210.	1513.
.6	15.68	31.36	78.40	156.8	313.6	470.4	627.2	784.0	940.8	1254.	1568.
.7	16.25	32.49	81.23	162.5	324.9	487.4	649.8	812.3	974.7	1300.	1625.
.8	16.82	33.64	84.10	168.2	336.4	504.6	672.8	841.0	1009.	1346.	1682.
.9	17.41	34.81	87.03	174.1	348.1	522.2	696.2	870.3	1044.	1392.	1741.
6.0	18.00	36.00	90.00	180.0	360.0	540.0	720.0	900 0	1080.	1440.	1800.
.1	18.61	37.21	93.03	186.1	372.1	558.2	744.2	930.3	1116.	1488.	1861.
.2	19 22	38 44	96.10	192.2	384.4	576.6	768.8	961 0	1153.	1538.	1922.
.3	19 85	39 69	99 23	198.5	396 9	595.4	793.8	992.3	1191.	1588.	1985.
.4	20.48	40.96	102.4	204.8	409.6	614.4	819.2	1024	1229.	1638.	2048.
6.5	21 13	42 25	105 6	211 3	422 5	633.8	845 0	1056.	1268.	1690.	2113.
.6	21 78	43 56	108 9	217 8	435 6	653.4	871 2	1089.	1307.	1742.	2178.
.7	22 45	44 89	112 2	224 5	448 9	673.4	897.8	1122.	1347.	1796.	2245.
.8	23 12	46 24	115 6	231 2	462 4	693 6	924 8	1156.	1387.	1850.	2312.
.9	23.81	47.61	119.0	238.1	476.1	714.2	952.2	1190.	1428.	1904.	2381.
7.0	24 50	49 00	122 5	245 0	490 0	735.0	980.0	1225.	1470.	1960.	2450.
.2	25 92	51.84	129 6	259 2	518 4	777 6	1037.	1296.	1555.	2074.	2592.
.4	27 38	54 76	136 9	273 8	547 6	821.4	1095.	1369.	1643.	2190.	2738.
.6	28 88	57 76	144 4	288 8	577 6	866 4	1155.	1444.	1733.	2310.	2888.
.8	30.42	60.84	152.1	304.2	608.4	912.6	1217.	1521.	1825.	2434.	3042.
8.0	32 00	64 00	160 0	320 0	640 0	960 0	1280.	1600.	1920.	2560.	3200.
.2	33 62	67 24	168 1	336 2	672 4	1009.	1345.	1681.	2017.	2690.	3362.
.4	35 28	70 56	176 4	352 8	705 6	1058.	1411.	1764.	2117.	2822.	3528.
.6	36 98	73 96	184 9	369 8	739 6	1109.	1479.	1849.	2219.	2958.	3698.
.8	38.72	77.44	193 6	387 2	774.4	1162.	1549.	1936.	2323.	3098.	3872.
9.0	40 50	81 00	202 5	405 0	810 0	1215.	1620.	2025.	2430.	3240.	4050.
.2	42 32	84 64	211 6	423 2	846 4	1270.	1693.	2116.	2539.	3386.	4232.
.4	44 18	88 36	220 9	441 8	883 6	1325.	1767.	2209.	2651.	3534.	4418.
.6	46 08	92 16	230 4	460 8	921 6	1382.	1843.	2304.	2765.	3686.	4608.
.8	48.02	96.04	240.1	480.2	960 4	1441.	1921.	2401.	2881.	3842.	4802.
10.0	50 00	100 0	250.0	500 0	1000.	1500.	2000.	2500.	3000.	4000.	5000.

Inasmuch as square root (L-10) charts do not record pressures in lb. per sq. in. directly, it is necessary to resort to the following formula to convert the L-10 readings to lb. per sq. in. (absolute):

$$P_A = P^2_L R_S \div 100$$

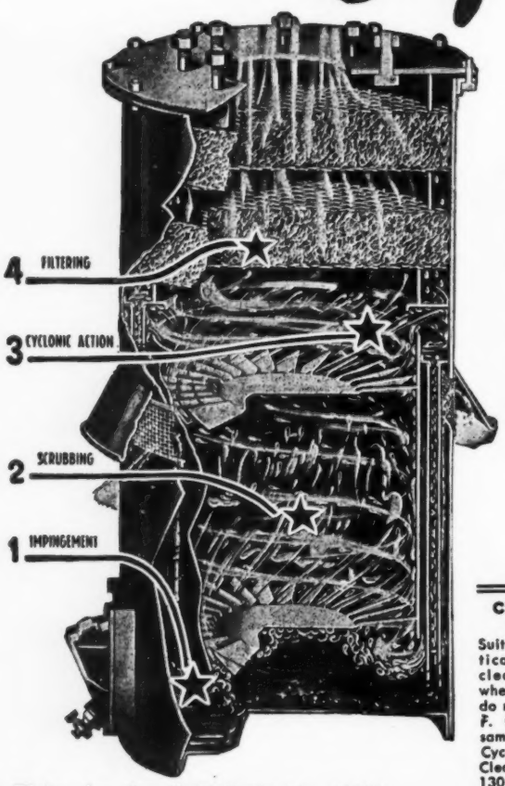
where: P_A = static pressure, lb. per sq. in. (abs.)
P_L = static pressure reading on (L-10) chart
R_S = range of static pressure element

To convert P_A to gauge pressure, subtract the atmospheric pressure in vicinity from above values of P_A.

Deduct atmospheric pressure in comparing meter reading with indicating gauge reading.

"OR EQUAL"

- does not apply to the *Cycoil*



Write for Cycoil Bulletin No. 130D which gives complete information on the operation of the Cycoil.

Judged by Performance Cycoil Cleaners have no equal . . . . . .

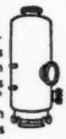
Its exclusive 4-way cleaning assures positive dust elimination under the most exacting conditions. In addition to its outstanding performance as an air cleaner the Cycoil is also effective as an intake silencer on either engines or compressors.

Engine manufacturers know the Cycoil and its exclusive advantages. If you specify them they will gladly equip your new engines with Cycoils.

Write for descriptive literature on all types of American Air Filters for engine and compressor protection. AAF manufactures a complete line of filters for every air cleaning need.

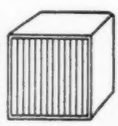
AMERICAN AIR FILTER COMPANY, INC.
19 Central Avenue, Louisville, Ky.

CYCOIL GAS CLEANER



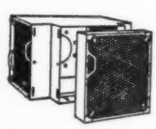
Suitable for practically every gas cleaning problem when temperatures do not exceed 140° F. Operates on same principle as Cycoil Oil Bath Air Cleaner. Ask for Bulletin 130D.

PL-H FILTER



Is a complete assembly consisting of housing, ready to bolt to intake pipe and dry cell type filters in which wool felt constitutes the filter medium. Ask for Bulletin 120D.

TYPE OCH FILTER



Complete assembly consisting of washable viscous impingement type filters. 1, 2, 3 or more cells are used, depending upon size of cleaning job. Ask for Bulletin 120D.

AMERICAN *Cycoil* AIR and GAS CLEANERS

GRAVITY OF DRY OIL IN OIL-WATER MIXTURES, DEG. A.P.I.

Gravity of "wet" oil, deg. A.P.I.	Percent water in mixture									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
45.0	45.04	45.09	45.13	45.18	45.22	45.26	45.31	45.35	45.40	45.44
.1	.15	.20	.24	.29	.33	.38	.42	.46	.51	.55
.2	.24	.29	.33	.38	.42	.46	.51	.55	.60	.64
.3	.35	.40	.44	.49	.53	.58	.62	.67	.71	.76
.4	.44	.49	.53	.58	.62	.66	.71	.75	.80	.85
45.5	45.55	45.60	45.64	45.69	45.73	45.78	45.82	45.87	45.91	45.96
.6	.64	.69	.73	.78	.82	.87	.91	.96	**46.00**	46.05
.7	.75	.80	.84	.89	.93	.98	46.02	46.07	.11	.16
.8	.84	.89	.93	.98	46.02	46.07	.11	.16	.20	.25
.9	.95	**46.00**	46.04	46.07	.13	.18	.23	.27	.32	.36
46.0	46.04	46.09	46.13	46.18	46.22	46.27	46.32	46.36	46.41	46.45
.1	.15	.20	.24	.29	.33	.38	.43	.47	.52	.57
.2	.24	.29	.33	.38	.43	.47	.52	.56	.61	.66
.3	.35	.40	.45	.50	.54	.58	.63	.68	.72	.77
.4	.44	.49	.54	.58	.63	.67	.72	.77	.81	.86
46.5	46.56	46.60	46.65	46.69	46.74	46.79	46.83	46.88	46.93	46.97
.6	.65	.69	.74	.78	.83	.88	.92	.97	47.02	47.07
.7	.74	.78	.83	.87	.92	.97	47.02	47.06	.11	.16
.8	.85	.89	.94	.98	47.03	47.08	.13	.18	.22	.27
.9	.94	.98	47.03	47.08	.13	.17	.22	.27	.31	.36
47.0	47.05	47.10	47.14	47.19	47.24	47.29	47.33	47.38	47.43	47.48
.1	.14	.19	.23	.28	.33	.38	.42	.47	.52	.57
.2	.25	.30	.35	.40	.44	.49	.54	.59	.63	.68
.3	.34	.39	.44	.49	.53	.58	.63	.68	.73	.77
.4	.46	.50	.55	.60	.65	.70	.74	.79	.84	.89
47.5	47.55	47.60	47.64	47.69	47.74	47.79	47.84	47.88	47.93	47.98
.6	.64	.69	.73	.78	.83	.88	.93	.98	48.02	48.07
.7	.75	.80	.85	.90	.94	.99	48.04	48.09	.14	.19
.8	.84	.89	.94	.99	48.04	48.09	.13	.18	.23	.28
.9	.96	48.01	48.05	48.10	.15	.20	.25	.30	.35	.40
48.0	48.05	48.10	48.15	48.19	48.24	48.29	48.34	48.39	48.44	48.49
.1	.14	.19	.24	.29	.33	.38	.43	.48	.53	.58
.2	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70
.3	.35	.39	.44	.49	.54	.59	.64	.69	.74	.79
.4	.46	.51	.56	.61	.66	.71	.76	.81	.86	.91
48.5	48.55	48.60	48.65	48.70	48.75	48.80	48.85	48.90	48.95	**49.00**
.6	.64	.69	.74	.79	.84	.89	.94	.99	49.04	.09
.7	.76	.81	.86	.91	.96	49.01	49.06	49.11	.16	.21
.8	.85	.90	.95	**49.00**	49.05	.10	.15	.20	.25	.30
.9	.94	48.99	49.04	.09	.14	.19	.24	.29	.34	.39
49.0	49.06	49.10	49.16	49.21	49.26	49.31	49.36	49.40	49.46	49.51
.1	.15	.20	.25	.30	.35	.40	.45	.50	.55	.61
.2	.24	.29	.34	.39	.44	.49	.55	.60	.65	.70
.3	.36	.41	.46	.51	.56	.61	.66	.71	.76	.82
.4	.45	.50	.55	.60	.65	.70	.76	.81	.86	.91
49.5	49.54	49.59	49.64	49.70	49.75	49.80	49.85	49.90	49.95	**50.00**
.6	.66	.71	.76	.81	.86	.91	.97	50.02	50.07	.12
.7	.75	.80	.85	.91	.96	50.01	50.06	.11	.16	.22
.8	.85	.90	.95	**50.00**	50.05	.10	.15	.21	.26	.31
.9	.96	50.01	50.06	.12	.17	.22	.27	.32	.38	.43

When tanks were only tractors with tin Hats—

Hyatts kept them going—*then*
Hyatts keep them going—*now*

TANKS . . . the "surprise weapon" of the Allies in the last war . . . were inspired by tractors with crawler treads perfected by Holt. Cushioning the shocks, keeping operating parts running true, Hyatt Roller Bearings helped carry the load and ably won their chevrons. Then back to "civvies," improved Hyatts have been doing their peace-time job well ever since. Therefore, these dependable bearings are again being drafted for tanks as well as army trucks, gun mounts, airplanes and other equipment in today's defense program. Hyatt Bearings Division, General Motors Sales Corporation, Harrison, N. J., Chicago, Pittsburgh, Detroit, San Francisco.

PHOTO BY U. S. ARMY SIGNAL CORPS.
Like tanks, Hyatts have been improved in design, but their traditional quality manufacture prevails even through "all out" production.

HYATT
Quiet
ROLLER BEARINGS

(At top) Allied photo taken "Somewhere on the Western Front," 1915 is that of a Holt Caterpillar Tractor with front wheel . . . prototype of present "Caterpillar" full crawler tractor of today.

Impulse Starting For Slow-Speed Horizontal Engines

PETROLEUM ENGINEER Exclusive Feature

☆ Combustible mixture of correct volume and quality serves to start engines without use of starting air equipment

THERE is a certain range of sizes in horizontal slow-speed one- or two-cylinder engines, in which the moving parts are so heavy that the engines cannot be started manually. Ordinarily when such engines are used it is customary to install a medium size air compressor and air storage tank or receiver.

Several companies, however, are using a means of starting such engines that eliminates the need for a large compressor and storage tank, thus reducing the investment costs involved in the installation.

In Figs. 1 and 2 are shown the only items of equipment required. The air compressor may be the smallest size available and it may be driven by a small gasoline engine of the type shown. The storage drum was field fabricated by welding together two 16-in. ellipsoidal heads.

The objective is to fill the small storage drum with a sufficient volume of air and gas so that when the mixture is admitted to the cylinder there will be sufficient energy to move the piston past the firing point, thus obtaining an explosion that will then turn the flywheel and place the engine in operation.

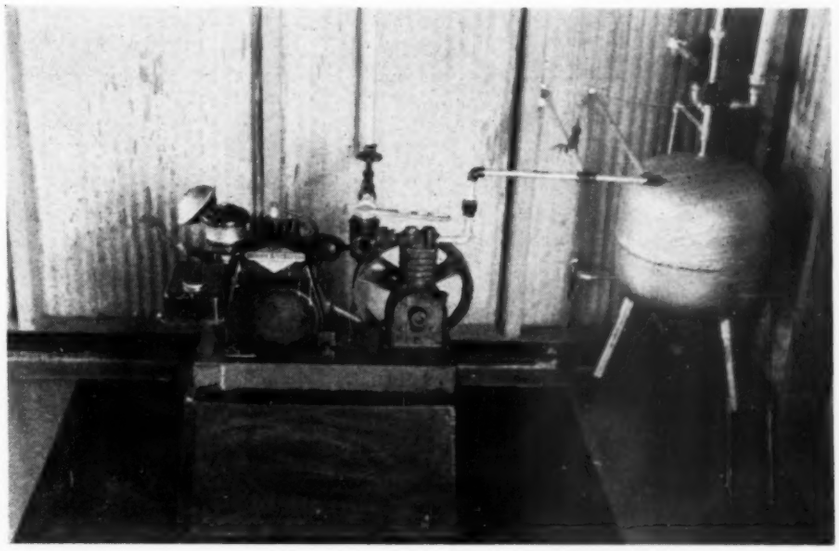


Fig. 1

It is a relatively simple calculation to determine the number of atmospheres of air and gas required to obtain the necessary volume and quality in the mixture. Beginning always, of course, with the size of the engine cylinder, it may be determined what pressure is required in the cylinder in order to move the piston. This will determine the number of atmospheres required in the cylinder and from this the volume in cu. ft. may be determined. Depending then upon the size of the pressure drum available, the number of atmospheres and from that the total pressure in lb. per sq. in. required on the vessel may be calculated.

Once the necessary calculations have been made and the required pressures determined the operator starting the engine needs only to perform the following duties:

1. Set the flywheel of the engine so that the piston is just ahead of the firing point.
2. Pump air into the pressure vessel until the required pressure is obtained.
3. Admit gas to the vessel until the total pressure is at the required figure.
4. Admit the mixture to the cylinder through the ¼-in. line shown in Fig. 3, that connects with the inlet port on the cylinder head.

This method of starting an engine not only reduces the equipment required but it eliminates entirely the possibility of backfiring that sometimes results in a cylinder head being blown off or cracked when excessive volumes of starting air are employed.

Fig. 2

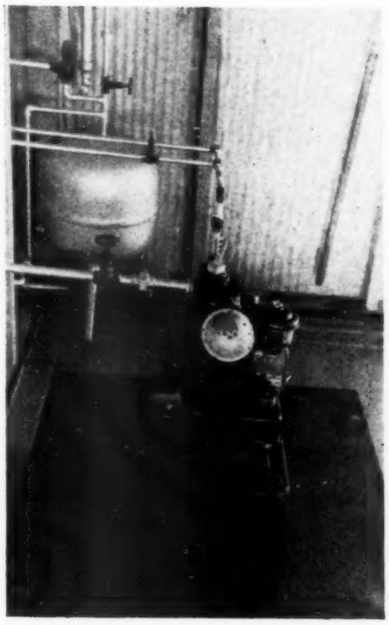
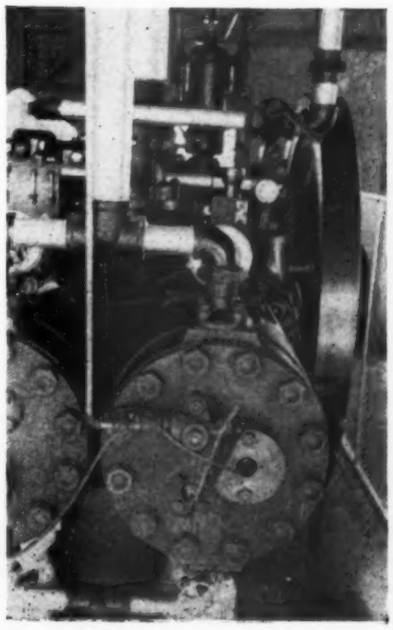


Fig. 3



LAUGH WITH BARNEY

A kindly old gentleman met a little boy carrying three puppies. He asked the little boy what their names were.

"Piddle, Puddle and Paderewski," replied the little boy.

"Well," replied the old gentleman, chuckling, "I can understand the first two as you have, but why name the third one Paderewski?"

"Because," replied the little boy, "he is the pianist."

A couple of girls handed the cashier of a cafeteria on their way out a slip of paper with the number 1004180 on it. This satisfied the cashier, who let them pass without paying. Why?

Well, it reads: "I owe nothing for I ate nothing."

Passenger: Porter, please wake me at five in the morning.

Porter: Boss, we aims to please. Any time you-all wants to be called, jes press dat button an' right away we comes an' calls you!

"Do you act toward your wife the same as you did before you were married?"

"Just the same. I remember when I first fell in love with her. I would lean over the fence of her house and gaze at her shadow on the curtain, afraid to go in. And I act exactly the same way now."

Rastus had been arrested for speeding. This was his fifth offense and as he was presented to the Judge, he muttered darkly under his breath. It sounded suspiciously like an oath.

"Repeat that!" thundered the Judge.

"Ah didn't say nothing," begged Rastus.

"You did say something and I want you to repeat it!"

"All ah says was God am de jedge, God am de jedge!"

The pretty young teacher was explaining the difference between concrete and abstract.

"Concrete means something you can see," she said, "abstract something you can't. Who'll give me an illustration?"

A boy in the first row raised his hand. "My pants are concrete," he said. "Yours are abstract."

A couple were sitting on the lawn admiring the scenic beauty.

"Some moon out tonight," said he.

"Some stars," said she.

"Some dew on the grass," said he.

"Hell, no, not me," said she—and left.

He (on phone): Hello, what are you doing?

Feminine Voice: Getting ready for church.

He: Sorry. Wrong number.

"Anyone on the next green, Caddie?"

"Yes, sir; there's a gentleman and his caddie and a man carrying his own clubs."

You can't kiss a girl unexpectedly; the nearest you can come to it is to kiss her before she thought you would.

"I guess I'll cut in on this dance," said the surgeon, as he chloroformed the St. Vitus patient.

Drunk (looking at moon's reflection in the water): What's that down there?

Cop: That's the moon.

Drunk: Mygosh, how did I get away up here?

Doctor: What was the most you ever weighed?

Patient: One hundred and fifty-four pounds.

Doctor: And what is the least you ever weighed?

Patient: Eight and one-quarter pounds.

Sonny: Ma says she could have soled her shoes with this steak I brought back.

Butcher (sarcastically): Why didn't she?

Sonny: 'Cause she couldn't get the nails through it.

A silk hosiery manufacturer and an aluminum household utensil manufacturer sat next to each other at the club. Both remained quiet for many minutes, gazing with worried and beaten expressions into space. Finally one of them gave vent to a long-drawn-out sigh. The other looked around sympathetically and said:

"You're telling me."

One can take a ride out in the country these evenings and see defense-minded couples conserving gasoline by parking along the road.

A reader wants to know if an editor is a man who puts things in the magazine. Land, no! An editor is a man who keeps things out of the magazine.

An inebriated man was trying to unlock the door of his house without success when a passing policeman asked if he could handle the key for him.

"Nope," the drunken man said, "I can hold the key. You hold the house."

The jury found the defendant guilty of burglary.

"Have you anything to say before I sentence you?" asked the judge.

"Only that I'm not guilty," replied the defendant, "and that I object to being identified by a fellow who had his head under the bed covers all the time I was in the room."

On the first morning after the honeymoon the husband rose early, went down to the kitchen and took his wife her breakfast in bed. She was delighted. Then hubby spoke: "Have you noticed every detail?"

"Of course, every single thing, darling!"

"Good. Well, that's how I want my breakfast served every morning after this."

I watched a business man signing letters. "Don't you read your letters before signing?" I asked in some astonishment. "Letters!" he exclaimed in surprise as he paused in his rapid autographing. "I thought these were affidavits."

"Goodness, George, this isn't our baby. This is the wrong carriage."

"Shut up. This is a better carriage."

"I'm losing my punch," said the flapper as she hurriedly left the cocktail party.

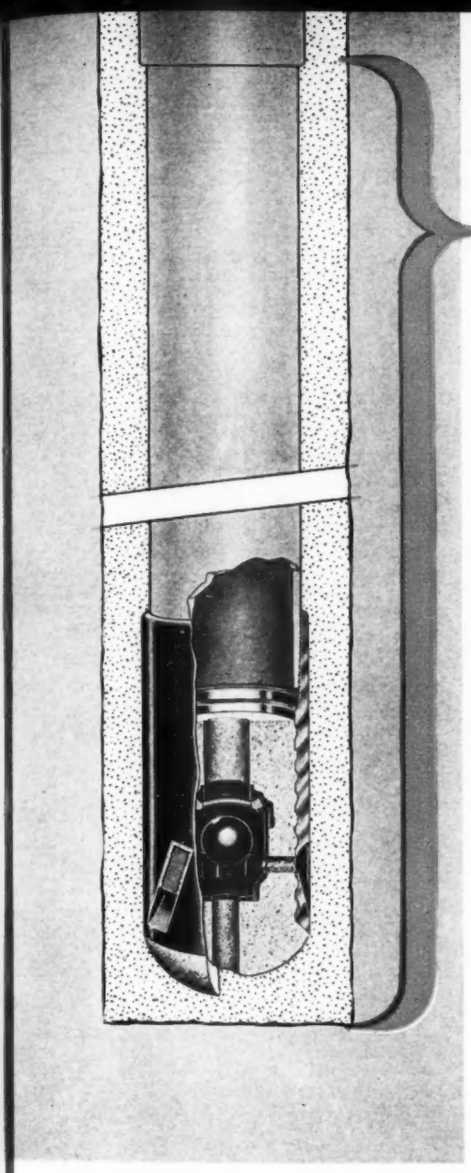
The visitor paid his green fee, fixed up a match and went to the first tee. Taking his stance, he gave a wild swing and missed completely.

"By Jove!" he said to his opponent. "It's a good thing that I found out early in the game that this course is at least two inches lower than the one I usually play on."

Judge: The jury having acquitted you of the charge of bigamy, you are free to leave the court and go home.

Prisoner: Thank you, your honor, but I want to be on the safe side—which home?

The best definition of a diplomat to be offered recently—a man who can convince his wife that a fur coat makes her look too fat.



DO THAT SHOE JOB *THE FIRST TIME* . . .

with a ★ BAKER CEMENT WASH-DOWN WHIRLER FLOAT SHOE

THE BEST TIME to do a cement job is the FIRST TIME . . . and field results have proved conclusively that the best chance for a successful "first time" job is by using Baker Cement Wash-Down Whirler Equipment.

The hazard of channeling can be reduced to a minimum if uniform cement distribution is secured at the critical cementing point, the shoe joint . . . and that's the assurance you have when a Baker Cement Wash-Down Whirler Shoe (usually in combination with a Baker Cement Float Collar) is on your casing string.

When the fluid strikes the baffled ports in a Baker Cement Wash-Down Whirler Float Shoe or Wash-Down Whirler Guide Shoe, a downward and then an upward whirling motion results. When running in casing, this whirling action provides a means of disintegrating and washing away bridges. When cementing, the whirling motion, imparted first to the fluid preceding the slurry and then to the slurry itself, washes the formation and properly prepares the hole. It then assures best possible distribution of a uniform body of cement around the shoe and the shoe joint. It is this uniform cement distribution that reduces the hazard of channeling to a minimum, and often saves a costly recement job.

For sales, service or information concerning Baker Cement Whirler Equipment, contact the nearest Baker office or field representative.

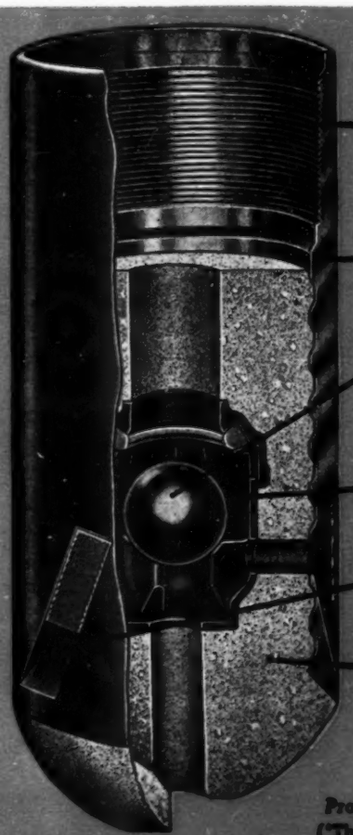
BAKER OIL TOOLS, INC.

MAIN OFFICE AND FACTORY: 6000 South Boyle Avenue
P. O. Box 127, Vernon Station, Los Angeles, Calif.
CENTRAL DIVISION OFFICE AND FACTORY: 6023 Navigation Boulevard
P. O. Box 3048, Houston, Texas
EXPORT SALES OFFICE: 19 Rector Street, New York, N. Y.

★ BAKER CEMENT WASH-DOWN WHIRLER FLOAT SHOE

SEE PAGES 222 AND 223 OF THE 1941 BAKER (OR COMPOSITE) CATALOG

BAKER
CEMENT GUIDING, FLOATING, CEMENTING EQUIPMENT



IMPORTANT FEATURES

(1) THREADED CONNECTION FURNISHED TO FIT ANY TYPE CASING. Baker Floating Units can be furnished with threaded connection to fit the specifications of your casing. (Float collars can be furnished with both "female" and "male and female" threaded connections.) Manufacturing precision assures thread uniformity and accuracy.

(2) STRENGTH. The seamless steel casing shoe into which the concrete plug and Plastic BALL-TYPE Valve Assembly are securely anchored, provides a unit that has the STRENGTH to float the longest and heaviest string of casing with an ample factor of SAFETY.

(3) POSITIVE, LEAK-PROOF BACK-PRESSURE VALVE. The buoyant Plastic BALL-TYPE Back-Pressure Valve floats in the cement slurry or rotary mud and instantly forms a leak-proof double seal against a narrow, tough rubber ring (backed by Plastic and concrete) at the slightest reversal of pressure. Here is Valve Efficiency at its best.

(4) AMPLE CIRCULATION AREAS. The correctly designed, streamlined Valve Assembly provides passageways ample for any circulating or cementing operation . . . a fact attested to by actual field performance under the most severe operating conditions.

(5) BAFFLED WHIRLER PORTS provide wash-down whirler action so important in washing away bridges, preparing formation to receive the slurry, and securing uniform cement distribution. Here is the ultimate in *Cementing Efficiency.*

(6) EASY DRILLABILITY results from the internal construction of Baker Formula Concrete and Plastic . . . the Plastic BALL-TYPE Valve Assembly being set on end in the concrete plug to present a minimum cross-sectional area to the drilling bit. The concrete and the Plastic are quickly drilled up and circulated out of the hole.

Product No. 120 — Baker Cement Wash-Down Whirler Float Shoe
(The Baker Wash-Down Whirler principle is also available in a Guide Shoe)

Running Tour

WITH MEN IN THE INDUSTRY

HOWARD F. STOVER, secretary-treasurer and general manager of the Gaso Pump and Burner Manufacturing Company, Tulsa, Oklahoma, was

HOWARD F. STOVER

elected chairman of the Oil Industries Committee of the Tulsa Chamber of Commerce at the committee's last meeting. He succeeds W. L. JAMES and is a former president of the Tulsa Purchasing Agent's Association.

JOS. L. MCHUGH, formerly director of the Minerals Division of the Conservation Division in the State of Louisiana, has been appointed by GOVERNOR SAM JONES to head the Department of Conservation as commissioner. McHugh succeeds W. H. HODGES, JR., who resigned.

HARVEY HERD, geologist with the Standard Oil Company of Texas, has been elected president of the Midland Geological Society succeeding B. A. RAY, Tide Water Associated Oil Company. B. G. MARTIN, Gulf Oil Corporation, has been named vice-president; EUGENE VANDERPOOL, Stanolind Oil and Gas Company, secretary-treasurer, and LANGDON TENNIS, independent geologist, speaker chairman.

H. H. POWER, University of Texas professor of petroleum engineering, has been appointed as an advisor to the oil conservation branch of the defense oil coördination program. Power will continue his work at the University and will be associated with E. L. DEGOLYER, Dallas, Texas, conservation director.

CHARLTON H. LYONS, Shreveport independent producer, will head the Louisiana-Arkansas Division of the Mid-Continent Oil and Gas Association, for another year. JOHN J. FROMMER, JOE T. GOODMAN, D. W. HARRIS, L. M. MOFFITT, and R. J. O'BRIEN have been elected vice-presidents, and A. R. CAMPBELL, secretary-treasurer. All the officers are of Shreveport, Louisiana.

C. L. BARRETT, Gulf Oil Corporation of Tulsa, Oklahoma, was named by the petroleum section of the National Safety Council at its Chicago, Illinois, meeting as chairman of the Mid-Continent Section. R. S. HUFFMAN, Oklahoma Natural Gas Company, was named chairman of the publicity committee.

ROBERT E. ALLEN, director of production in the federal petroleum coordinator's office, announced that 5 authorities on natural gas have volunteered to serve as district chiefs of a newly formed Natural Gas Section under his direction. FRANK BREWSTER, Bradford, Pennsylvania, will head District 1 with headquarters in New York, New York; W. K. WARREN, Tulsa, Oklahoma, District 2, headquarters in Chicago, Illinois; D. E. BUCHANAN, Tulsa, District 3, headquarters in Houston, Texas; ROBERT HENDEE, Colorado Springs, Colorado, District 4, headquarters in Denver, Colorado, and WILLIAM MOELLER, Los Angeles, California, District 5, with headquarters in Los Angeles. Purpose of the section is the production of more industrial gas.

WILLIAM K. WHITEFORD, Tulsa, Oklahoma, executive vice-president of the British American Oil Producing Company and the Toronto Pipe Line Company, two subsidiaries of the British American Oil Company, Ltd., will transfer his office to Toronto, Canada, about the first of the year. A. L. ELLSWORTH, president, feels that Whiteford is needed in Canada to coördinate the work between the parent company and subsidiaries in the United States. HENRY C. ARNOLD, vice-president in charge of land and geological departments, will become acting vice-president while Whiteford is in Canada for an indefinite period.

DR. RICHARD J. GONZALEZ, Humble Oil and Refining Company, Houston, Texas, delivered an address on "The Importance of the Petroleum Industry to the Economy of Texas," at the annual meeting of the Texas Statistical Council held at the University of Texas, Austin.

DR. C. D. LOWRY, JR., Universal Oil Products Company, addressed the Wichita, Kansas, section of the American Chemical Society on "The Newer Chemistry of Petroleum Gases." He discussed the bearing of this newer chemistry on the production of special products for national defense.

EMBY KAYE, president of Distillate Engineering and Process Company, Tulsa, Oklahoma, delivered an informal address on "Recent Surveys of Recycling Activities" to the Tulsa Geological Society, at a recent meeting of the group.

W. J. KLECKNER, formerly in charge of the drilling in Michigan for the Gulf Oil Corporation, was recently transferred to Fairfield, Illinois.

D. D. PICKRELL, independent operator of Houston, Texas, is now superintendent for the Premier Refining

D. D. PICKRELL

Company in the pipe-line department at Ranger, Texas.

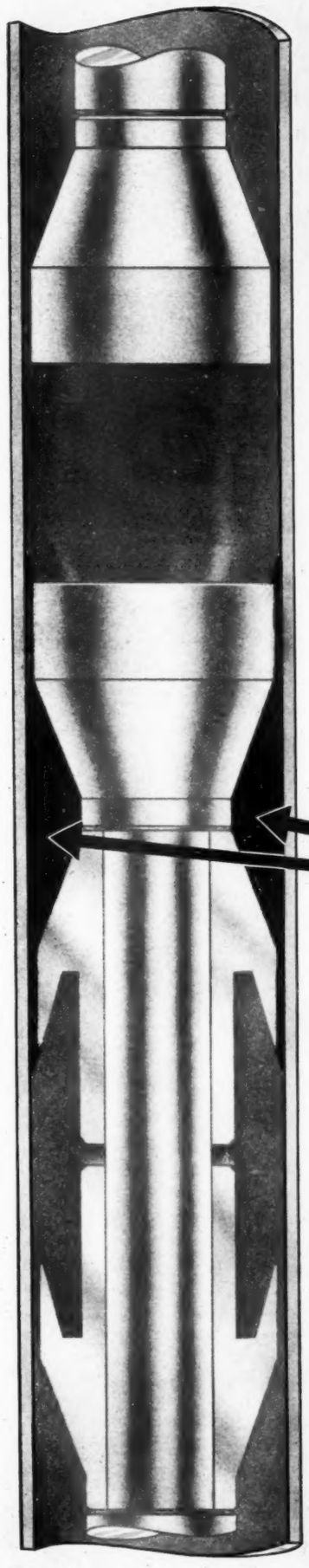
LARGE FLUID PASSAGE

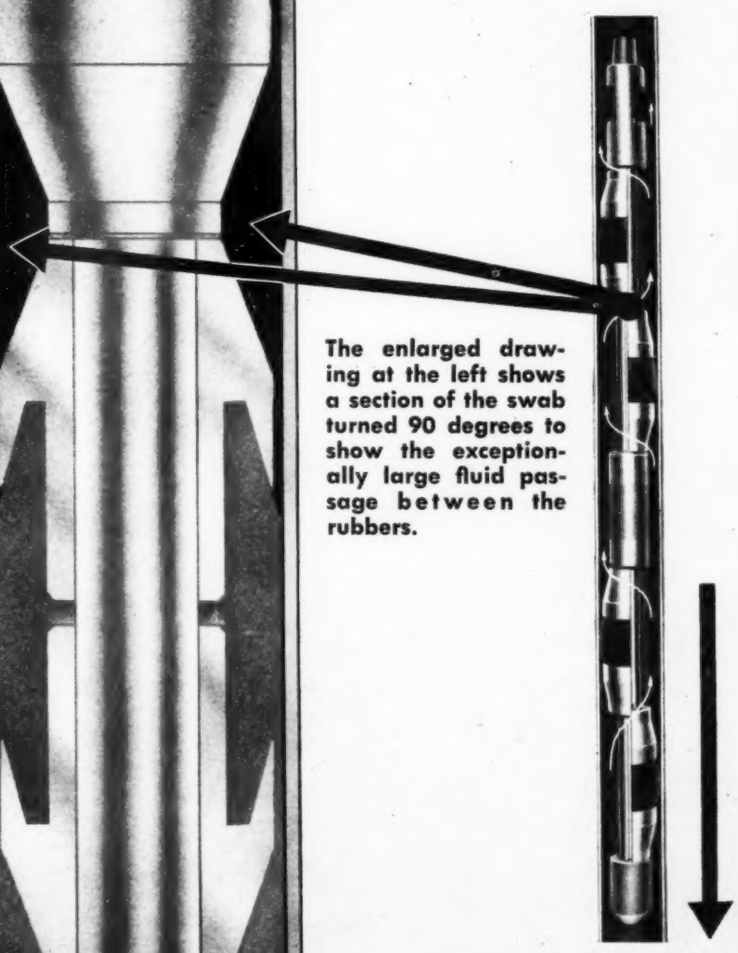
This exceptionally large fluid passage through Mission Valveless Swabs permits faster falling—faster falling results in faster round trips and lower swabbing costs.

In addition to faster round trips, you get faster swabbing because the rugged construction of these swabs permits you to lift more fluid each trip.

Try Mission Valveless Swabs on your next job and see how much they reduce your swabbing costs. You can get Mission Swabs at your favorite supply store. Mission Manufacturing Company, Houston, Texas. Export Office: 30 Rockefeller Plaza, New York.

You Swab Faster and Safer With
MISSION
VALVELESS SWABS





The enlarged drawing at the left shows a section of the swab turned 90 degrees to show the exceptionally large fluid passage between the rubbers.

GOING DOWN: The large fluid passage through Mission Valveless Swabs permits faster falling, faster round trips and faster swabbing.

LIFTING THE LOAD: Heavy duty rubbers and rugged swab construction permits you to lift a heavier load each trip—thus reducing the number of trips necessary.

THOMAS R. WEYMOUTH was awarded the Charles A. Munroe Award at the American Gas Association's annual meeting in Atlantic City, New Jersey, for having made the most outstanding recent contribution toward the advancement of the gas industry. The award consisted of a substantial financial acknowledgment and engrossed certificate and was made to Weymouth for his leadership of organized research activities and for his individual accomplishments of a fundamental and permanent nature. After a distinguished career in the natural gas industry, Weymouth resigned April 1 as vice-president of the Columbia Gas and Electric Corporation, New York, New York. C. L. CAMPBELL, chairman, F. H. LERCH, JR., and D. A. HULCY were the members of the Munroe Award Committee.

THOMAS R. WEYMOUTH

J. E. BRANTLY of Los Angeles, California, president of Drilling and Exploration Company, discussed operating conditions in South American oil fields at a recent luncheon of the Petroleum Club of Dallas, Texas. His talk covered in general the various problems met by drillers in South America, particularly in transportation, and their solution. Brantly has spent much of the last 25 years on the lower continent.

O. H. CREWS, University of Oklahoma petroleum engineering graduate and formerly with British American Oil Producing Company, is now with International Petroleum Corporation at Talara, Peru.

HALBERT M. MCCLAIN, Magnolia Petroleum Company chemical engineer, has been transferred from Oklahoma City, Oklahoma, to Dallas, Texas, and is in charge of production engineering, new unit of the producing division.

C. B. WILLIAMS has returned to the United States as division manager for The Texas Company at Fort Worth, Texas, succeeding H. S. COLE, JR., who is now assistant to L. E. BARROWS, manager of the production division. Williams has been in charge of the Barco Concession in Colombia for The Texas Company.

A. ARUTUNOFF, Reda Pump Company president, Bartlesville, Oklahoma, recently delivered an address before the American Institute of Electrical Engineers at Dallas, Texas.

H. M. STALCUP, Skelly Oil Company, Tulsa, Oklahoma, has been appointed chairman of the general committee on arrangements for the spring meeting of the Mid-Continent District of the American Petroleum Institute Division of Production to be held in Tulsa, March 26 and 27, 1942. C. D. MILLER, Barnsdall Oil Company, was appointed program chairman; H. W. LADD, Stanolind Oil and Gas Company, registration chairman; A. J. KERR, Pittsburgh Equitable Meter Company, meeting room facilities; DEE SYKES, Baroid Sales Company, entertainment, and C. O. WILLSON, *The Oil and Gas Journal*, publicity.

J. K. ROBERTS, director of research for the Standard Oil Company of Indiana, has been renamed as chairman of the Petroleum Division of the American Chemical Society at its recent meeting.

WALTER A. PARRISH was recently appointed executive engineer of Superior Engine Division by National Supply Company with headquarters at the Springfield, Ohio, plant. He was formerly with Cummins Engine Company at Columbus, Indiana, as assistant chief engineer.

JACK W. GREEN is the new manager of the Chicago office and surrounding territory for Tube-Turns, Inc., Louisville, Kentucky. He had been with American Radiator and Standard Sanitary Corporation more than 12 years.

SAM M. GREENIDGE, Texas Pacific Coal and Oil Company petroleum engineer and tax commissioner, has been elected executive vice-president of the Petroleum Engineers Club of Fort Worth, Texas. He will complete the unexpired term of JOHN WILMOT, recently transferred to Wichita Falls by The Texas Company.

EDWARD STEWART, Mt. Pleasant, Michigan, producer and contractor and head of Stewart Oil Company, has been appointed to the Michigan Oil Advisory Board. He succeeds C. A. SMITH, JR., president of Smith Petroleum Company, Grand Rapids, Michigan, who has moved to Chester, West Virginia.

ARTHUR LEVY, Fohs Oil Company; G. B. SCHNEIDER and W. C. THOMPSON, General Crude Oil Company; PAUL WEAVER and DR. F. M. SEIBERT, Gulf Oil Corporation; HARRY WIESS, FRANK WATTS, GEO. CORLISS, and BOB BRIDGES, Humble Oil and Refining Company; CHARLES BROWN and I. W. ALCORN, Pure Oil Company; A. J. GALLOWAY, Shell Oil Company; A. M. MCCORKLE, Stanolind Oil and Gas Company, and W. B. HEROY, Pilgrim Exploration Company, were guests of the Dow Chemical Company recently on a tour through the Freeport, Texas, plant to inspect the process used to extract magnesium from sea water and oyster shells. At the Dow Hotel after a luncheon for the visitors, A. P. BEUTEL, general manager of the Freeport plant and president of Dowell Inc., discussed the process and projected plant enlargement. A chartered bus took the group to the plant for the tour. Dowell Inc. men attending were N. R. CRAWFORD, vice-president and general manager, M. L. STIRLING and F. I. MCCONNELL, assistant sales managers, STANLEY MORIAN, district sales engineer, and CHARLES REED, branch sales manager for Dow Chemical Company in Texas.

RALPH C. GRAHAM

RALPH C. GRAHAM has recently been appointed division engineer by British American Oil Producing Company with headquarters at Wichita Falls, Texas. Graham formerly was with Carter Oil Company in Oklahoma and Illinois for a number of years. More recently he was associated with Security Engineering Company at Whittier, California, and Houston, Texas, in connection with engineering problems involving drillable metal products.

around the bend there's SAFETY

for a fresh start stop at a HOTEL

The highways call you to adventure by day - but at night, **PLAY SAFE!** When you are lured by cheap prices, stop and consider the security and protection you need. Throughout America there are thousands of modern A·H·A hotels, providing you with real comfort and real protection - and for the slight extra cost you receive many times more than your money's worth in enjoyment, peace of mind, rest and extra zest for the journey ahead.

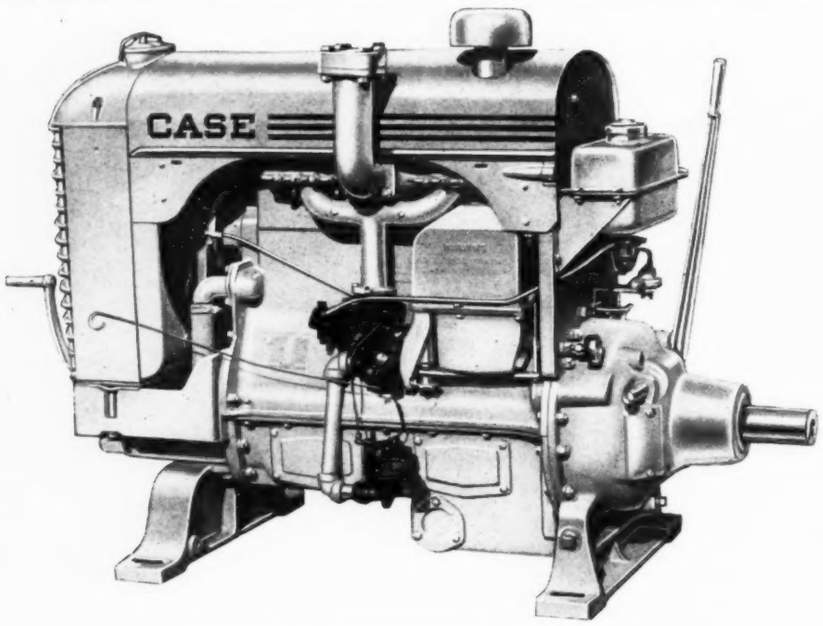
AMERICAN HOTEL · AHA · ASSOCIATION

MACHINERY and EQUIPMENT

Improved Case Oilfield Engines

TWO improved oilfield engines for well-pumping service have been announced by the J. I. Case Company, of Racine, Wisconsin. The Model DE supersedes the Model CE and develops 35 hp. at 1100 r.p.m. when operated on natural gas. The new engine has a 3⅞-in. bore and 5½-in. stroke and is a 4-cylinder engine having 259.5 cu. in. piston displacement.

The Model LAE replaces the previous Model LE engine and develops 55 hp. on natural gas at 1100 r.p.m. It has a 4⅝-in. bore and 6-in. stroke with 403.4 cu. in. piston displacement. It also is a 4-cylinder engine.



Both engines are provided with increased cooling capacity and larger clutch shaft and clutch shaft bearings. They are now streamlined for improved appearance and a grill and bug screen are mounted in the front of the radiator.

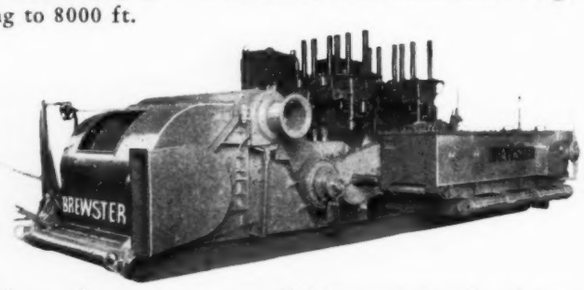
Special equipment is provided to reduce the formation of sludge and condensate in the crankcase. Both models are equipped with high-temperature water line thermostats and also vertical metal shutters in front of the radiator so that adequate operating temperatures can be maintained with the engines operating exposed to the weather. Two liberal hand holes are provided on each side of the engines giving easy access to the crankcase for cleanout purposes and for making repairs. These are arranged so that the pistons and the wet type cylinder liners can be removed and replaced in the engine without having to drop the oil pan or remove the engine from its base. The oil pump screen can be cleaned by removing three bolts from the side of the oil pan without having to drop the oil pan or get into the crankcase of the engine for this operation.

The J. I. Case Company advise that ample stock of these new engines is available for prompt delivery from the warehouses of their Texas oilfield distributor, The Southwest Equipment Company at Dallas and Kilgore, Texas.

Brewster's VO-200 Rig

THE new Brewster VO-200 rig is said by the manufacturer to be tougher, more compact, and more powerful than former models and is designed for easy drilling to 8000 ft.

Featured on this new Brewster rig is a 500-hp. completely oilbath lubricated compound for the two 225-hp. motors. An oilbath transmission is also employed, having 4 speeds forward and 1 reverse.



To add flexibility and ease of operation, friction clutches are used on the rotary drive, drawworks drive, and pump drive. The pump drive has two speeds.

Other features include: 10-in. by 46-in. watercooled brakes; 7½-in. drumshaft of alloy-steel, heat-treated, and extended for mounting hydromatic brake; roller chains used throughout on all drives, compound, and transmission.

The rig is manufactured by The Brewster Company, Shreveport, Louisiana.

Sleevoil Precision Pillow Blocks

THE NEW Sleevoil Precision Pillow Blocks, made by Dodge Manufacturing Corporation, Mishawaka, Indiana, in plain and water-cooled types in shaft sizes from $1\frac{7}{16}$ in. to 8 in., inclusive, are designed for a wide range of industrial applications where a high grade babbitted bearing is required.

Ample lubrication is provided by the use of "T" section brass oiling rings. Single rings are supplied in sizes to $3\frac{7}{16}$ in. and two rings are used in larger sizes. A brass oil gauge is provided that can be placed on either side of the bear-

ing and by the use of additional ½-in. pipe can be extended to any distance from the bearing. Bases have drain holes in each end and caps are provided with inspection hole and cover.

These bearings are fully self-aligning and can be supplied either in expansion or non-expansion types. Expansion pillow blocks have no provision for thrust loads but the non-expansion bearings are supplied with two internal split thrust collars. This type should be used as an anchor bearing and other bearings on the same shaft should be of the expansion type.

Effective sealing against admission of dirt or escape of lubricant is provided by special seals held onto the shaft by garter springs so that they revolve with the shaft and give the effect of piston ring seals. A drain is provided at the bottom of the seal grooves to carry oil back to the oil chamber.

The bases, ends, and spherical seats of Sleevoil Pillow Blocks are finished and dowel pin holes are provided.

Sleevoil Water Cooled Pillow Blocks are identical in design and construction with the plain types except for the water-cooled feature, which makes them particularly adaptable for service where high temperatures, heavy loads, or rubbing speeds are encountered.

Sizes to and including $3\frac{15}{16}$ in. are water cooled in the lower liner only and have one flexible inlet and one outlet connection. Sizes $4\frac{7}{16}$ in. and larger are water cooled in both upper and lower liners and have two flexible inlet and two outlet connections.

Both plain and water-cooled types are regularly carried in stock in sizes to and including $3\frac{15}{16}$ in.

Anchor Type Elastic Stop Nuts Now Available

As a result of the successful use of their anchor type nuts in aircraft construction, Elastic Stop Nut Corporation, 2332 Vauxhall Road, Union, New Jersey, now offers these nuts for blind-mounting applications on general industrial equipment.

Designed to provide vibration-proof fastenings for removable plates used to

cover hand holes, access and inspection openings, and for other blind mount attachments, anchor nuts are permanently riveted to the inside of the structure. The bolts, which are inserted from the outside, pass first through the removable plate, thence through the structure into the stationary nuts.

These nuts are offered in a wide range every nut incorporating the basic Elasof size, material and thread system, tic Stop self-locking feature, a fiber locking collar that is an integral part of each nut. This locking fiber prevents the bolt from becoming loose after it is installed in the nut, regardless of the severity of the vibration to which it is subjected, it is stated. In such mountings, the bolts may be removed and replaced many times, the anchor nuts retaining their locking ability because of the resilient character of the fiber collar. It is pointed out, too, that the fibre of the collar, being softer than the metal of the screw, cannot damage the threads or their plated surfaces.

As with other Elastic Stop Nuts, when the end of the bolt enters the unthreaded collar, its passage is resisted, thus immediately and automatically eliminating all play between the threads of bolt and nut, and establishing contact of the load-carrying threads under pressure. Further turning and tightening of the bolt impresses a thread in the fiber collar, creating a moisture-tight seal around the bolt and maintaining the thread contact with a resilient grip. The braking action of the collar itself serves further to prevent any backing out of the screw.

POSITIVE
AUTOMATIC SEAL
at Any Pressure
Grizzly Pressure Seal [Patent No. 2,151,307]. Seepage of fluid under pressure into clearance between Adapter "A" and Coupling Flange "B" at "C" forces the specially designed terminal of hose body firmly against the Adapter and Coupling walls at "D" and "E" and forms a positive automatic seal at any pressure.
PRESSURE SEAL
3" GRIZZLY POWERFLEX

Grizzly Pressure Seal Rotary Hose embodies the new Pressure Seal Coupling, light in weight, built integral with the hose and its steel armor in such a manner that it is impossible for the coupling to pull out, blow out or leak at this vital point. The seal, accomplished by the fluid within the hose, is effective at pressures practically nil and extreme high pressures only serve to strengthen the seal. Rigid steel to steel construction between adapter and coupling eliminates any possibility of damaging hose by pinching. A complete trouble-proof unit ready for *full-protection* service. Forget hose troubles—use Grizzly and save. Write for Bulletin No. 20-OF.

Above: A 50 ft. length of Grizzly 3" Pressure Seal Rotary Hose, soaked out on factory floor, with no strain or kinks at any point, demonstrating its extraordinary flexibility.

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Continental Emsco Co., 30 Rockefeller Plaza, New York City
Distributed by Leading Supply Companies.

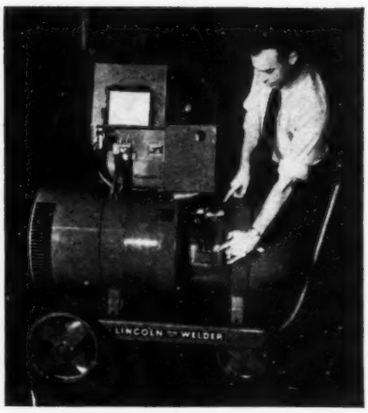
GRIZZLY
REG U. S. PAT OFF
PRESSURE-SEAL ROTARY HOSE

Lincoln Protective Control Device

COMPLETE protection against heat or excessive current, or both, is provided by a new protective control device for arc-welding machines announced by The Lincoln Electric Company, Cleveland, Ohio.

According to the manufacturer, the new development creates advantages not previously available. It is said that a welding machine equipped with this new Lincoln device, which provides protection against burn-out, can be operated at maximum capacity for long periods without harm.

The protective control device (see accompanying illustration), consists of two current transformers (upper devices in illustration), the primaries of which are connected in series with the motor leads and the secondaries supplying power to operate two snap-action thermostats that are mounted directly on the motor lamination (lower device in illustration). These thermostats are connected to the lamination in such a way that they operate by means of heat conduction as well as by current passing through the thermostat.



The protection provided by this device is explained by the manufacturer as follows:

1. If the welder is being operated in a very hot room or an oven and exceeds the safe operating temperature, thermostats will trip open.
2. If the motor is cold and excessive currents that will eventually damage the motor occur for a short period of time, the thermostat will operate before the motor reaches an unsafe temperature.
3. If the machine is started on single phase lines, the switch may close, but the excessive heating of the thermostat caused by the single phase locked current will open the thermostat and stop the machine.
4. If the machine is running and one fuse blows so that the motor is operating single phase, if the load on the machine is sufficient to overheat the motor, the thermostats will trip out.
5. If the rotor is locked with normal three phase power applied, the thermostats will open the circuit due to the high current.
6. If the welder is operated for long periods of time at sustained overloads, both high input current and high motor temperature combine to open the thermostats.

The thermostats automatically reset when the motor returns to a safe operating temperature or when the current is reduced, and no manual operation is required to start the machine, except pushing the start button.

A special circuit allows the starter button to be held "in" after the welder thermostats have been tripped. This allows the machine to rotate with no load and the welder ventilation speeds up the cooling of the welder after the trouble has been rectified.

Drilling operators and geologists alike find it indispensable because it THOROUGHLY reconditions mud and provides TRUE SAMPLES of foot by foot cuttings. In fact, taking samples from this machine *is as simple as reading a log.* The big economy feature—it operates entirely from flow of mud, eliminating the necessity of motors and auxiliary power units. Now in use by major oil companies and independent drilling operators. GUARANTEED to give satisfactory performance. Write for full details and prices NOW.

Manufactured by
THOMPSON TOOL CO., INC.
Sold Through Supply Stores Everywhere
Phone 3521 Iowa Park, Texas

Otis Wire Line Tubing Perforator Service and Packoff Anchor

THE Otis Wire Line Tubing Perforator Service and Packoff Anchor provide a means of removing mud or water from back of a casing packer without contaminating or exposing the lower pay and make possible the use of the casing annulus to inject gas to flow the well. The complete operation is made under pressure with an ordinary steel measuring line and does not require erecting derrick, moving tubing, or breaking packer seal.

The most common usage for this tool is in wells where the gas pressure has been depleted to such an extent that the oil column loads up in the tubing, making it necessary to kick off the well with some external source of gas. Where such conditions exist, it has become a very common operation to set a removable tubing stop just above the packer, drop in a back-pressure valve to keep the mud off the sand face, cut holes in the tubing with an Otis Perforator, using the stop as a base, circulate all the mud out of the casing annulus, and through the annulus inject gas to kick off the well. The packoff anchor is run to regulate the gas entering the tubing through the perforations.

The wire-line tubing perforator consists of a wedge, two knives, and a knife base. The taper of the tapered wedge is sufficiently small to cause the impacts from an ordinary set of tubing jars to force the two knives through the tubing walls. The knives retract with an upward pull on the line, permitting the tools to be easily removed.

The packoff anchor consists of two parts, a packoff section and the tubing stop. The purpose of the packoff section is to control the flow through the tubing perforations, whereas the tubing stop serves two purposes: first, as a stop and base for the perforating job, and, secondly, as an anchor and guide for the packoff section.

The removable tubing stop is simply a tapered mandrel on which are mounted three slips held together by a slip carrier. The slips point downward and utilize all downward forces and impacts to further secure the lock. The stop is run and pulled with a Type H Otis Running Tool.

The packoff section consists of two sealing cup assemblies connected by a spacer nipple. The tool is designed so that when it sets down on the stop one cup assembly is above and the other below the tubing perforations. This restricts all flow through the perforations to that which will pass through the orifice between the cup assemblies. The packoff section is run with an Otis H Running Tool and pulled with an Otis Choke Extractor.

Proportioning Controller for Throttling Fuel Heat

C. J. TAGLIABUE Manufacturing Company, Brooklyn, New York, announces the development of a new Proportional Controller for applications in which throttling control with or without automatic reset is required. The manufacturer reports that the new system of control employs only a control instrument and a valve mechanism, eliminating the relay detector element formerly required.

The simple method for throttling control accomplished by this instrument may be briefly described as fol-

The Protectors with LIPS that talk service

The Lips add 15% more gripping area.

Maximum streamlining by eliminating flat ends.

Thin Lip edges eliminate mud and chemicals from lodging.

Swirling action of mud occurs on Protector instead of on pipe.

Grooving or "ringing" of drill pipe avoided.

An extra, exclusive improvement at no added cost.

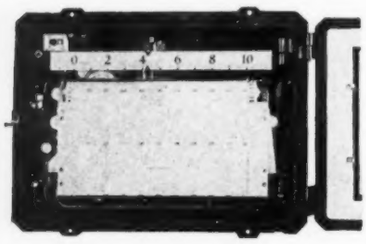
REQUEST FULL DETAILS *SEE COMPOSITE CATALOG*

PATTERSON-BALLAGH LIP PROTECTORS

PATTERSON-BALLAGH CORPORATION

Los Angeles Houston New York City

lows: When the temperature is far below the control point as in starting up, the valve will be wide open; as



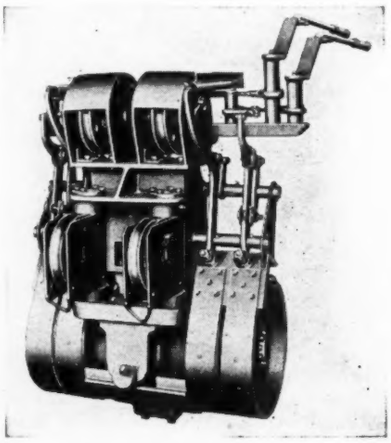
the temperature rises and enters the throttling zone, the valve will close a relay. This action prevents overshooting as the temperature approaches a balance between heat input and heat loss. The throttling zone can be readily adjusted within wide limits according to the lag characteristics of the application and the maximum permissible sensitivity, easily determined in order that the load error be kept within a few degrees on those models without reset. Other types with adjustment for manual reset (load error) or automatic reset are available.

It is asserted that these instruments maintain practically "straight line" control because Celectray Controllers have the smallest "dead zone."

Buckeye Announces New Controls for Model HD Hoist

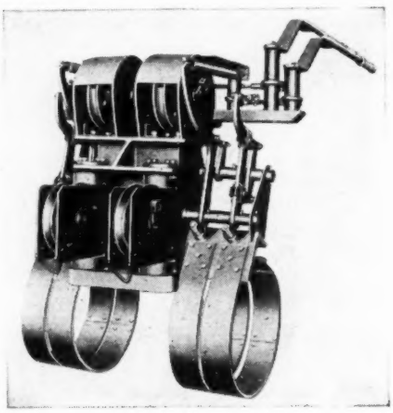
THE Buckeye Traction Ditcher Company, Findlay, Ohio, announces an improvement in the design of the control levers and linkage on Buckeye Model HD (heavy-duty) power control units for Allis-Chalmers, Cletrac, and Caterpillar tractors.

The change incorporates relocated



Complete Buckeye HD hoist

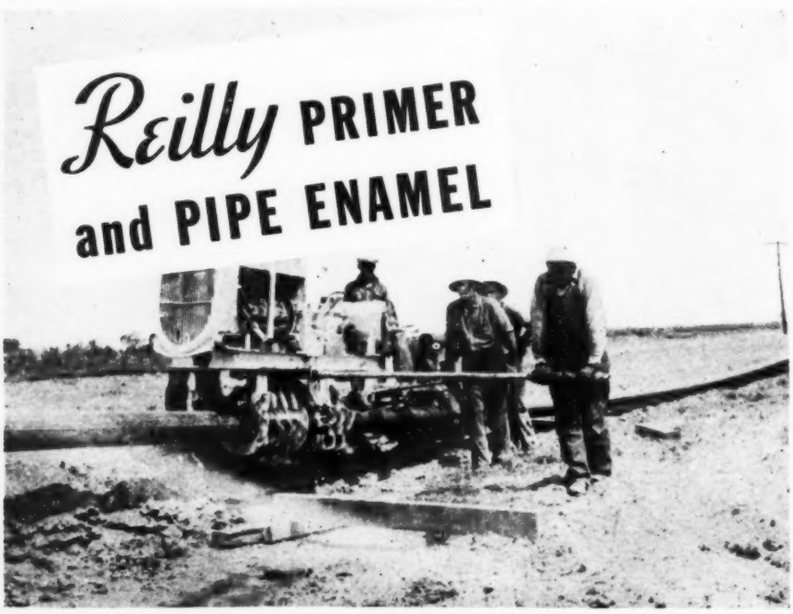
horizontal control levers that are placed within easier reach of the operator. Better leverage is now obtained and operation is simpler and more positive, it is stated. The fair lead swivel sheaves have been lowered, thus bringing the



Replacement parts available for modernizing the old style HD hoist

direct line pull closer to the tractor drawbar, resulting in better tractor balance.

Complete control lever and linkage assemblies are interchangeable with the older style mechanisms and are available for replacing them.



POSITIVE PROTECTION
for Oil and Gas Pipe Lines

● Engineers in charge of construction of oil and gas transportation lines, in all sections of the country, have found that coatings of Reilly coal tar enamel offer the best protection against rust and corrosion.

REILLY PRIMER and PIPE ENAMEL, produced from coal tar, bond firmly to the metal, providing a smooth, tough coating that is highly resistant to abrasion and soil stress. This coating will withstand temperatures as low as minus 20°F., without checking or cracking, and temperatures as high as 160° to 170° without flow or sag. Reilly coatings are easily applied by all conventional methods. Write for booklet describing all of these products.

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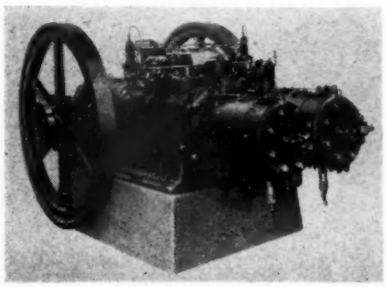
FIFTEEN · PLANTS · TO · SERVE · YOU

Horizontal Engines

THE Cooper-Bessemer Type GA Horizontal Engines, manufactured by the Cooper-Bessemer Corporation, Mount Vernon, Ohio, are supplied in seven different units but all come under one basic design. Four of these units are available as gas engines, two as Diesels, and one as a semi-Diesel. Their power ratings range from 25 to 150 hp. and though their bore and stroke, size and number of cylinders, and type of fuel may differ, the same fundamental construction principles are followed. Although this type engine has been tested and proved in every kind of power application within the horsepower range over a period of years, improvements have been made



and better materials have been developed for their construction.

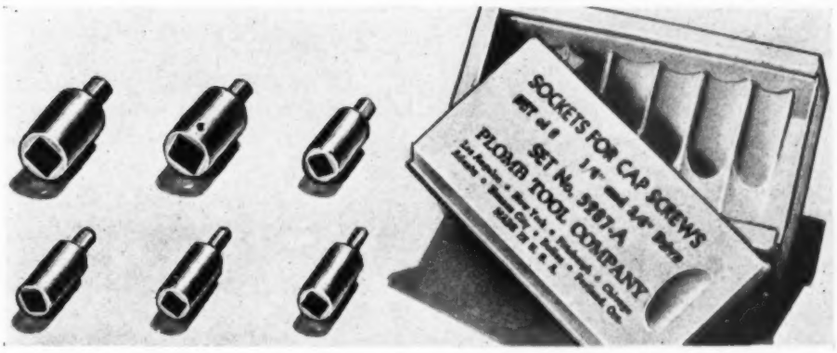
Features asserted for this type of engine include (1) main crossheads of alloy-steel castings fitted with an adjustable, bronze-bottom shoe; (2) flywheels made of Meehanite Metal and in two weights; (3) metallic piston rod packing; (4) force-feed lubrication of power cylinders by means of a built-in force-feed pump; (5) all accessories are layshaft driven; (6) starting accomplished by use of an automatic air-starting valve; (7) Meehanite Metal used in all cast-iron parts, and (8) convertibility from gas to Diesel and Diesel to gas.

Plomb Sockets

SOCKETS for all popular sizes of socket head cap screws and set screws (Allen type) are now available in the Plomb line of hand tools. These new sockets are made for use with various types of Plomb attachments.

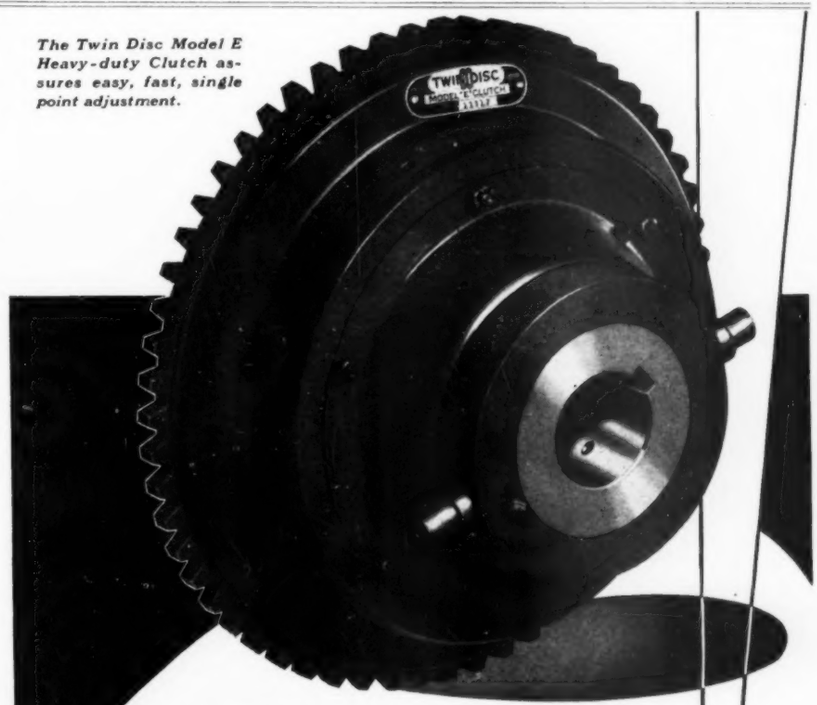
Socket sizes are from ¼ to ⅝ in. for hexagon opening from ⅛ to ⅜ in.

Special alloy steel is used for endurance and strength in meeting the unusual conditions involved. The drive plug is made separately from the socket part, and is held in position by a small set screw. In event the drive plug breaks, it is therefore very simple to remove it and insert a new one, thus saving the original socket part.



Additional information may be obtained from the Plomb Tool Company, 2209 Santa Fe Avenue, Los Angeles, California.

The Twin Disc Model E Heavy-duty Clutch assures easy, fast, single point adjustment.



No Projecting Parts

. . . that require special guards or housings

• The mechanism of the Twin Disc Model E Heavy-duty Clutch is fully enclosed. This not only protects the working parts from undue dirt and moisture but provides an added safety factor. At the same time the design of the Model E Clutch allows for a maximum air circulation for heat dissipation. This is but one of the features which is responsible for the wide use of Twin Disc Clutches in all types of oil field equipment. TWIN DISC CLUTCH COMPANY, 1329 Racine Street, Racine, Wisconsin.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U.S. PAT. OFF.

"Plug" Parrish Passes Away

Benjamin Eugene "Plug" Parrish, 52, died October 14 in Dallas, Texas. Parrish, born in Honey Grove, Texas, in 1889, had spent his entire working life in the oil business. He was a drilling contractor for many years and followed numerous oil booms. An operator in Mexico for some years, Parrish formed the Parrish Plugging and Security Company. Regarded as an inventive genius he received his nickname "Plug" from his invention of the Parrish Plug. During the last nine years of his residence in Mexico, Parrish was vice-president of the Marland Consolidated Oil Company, subsidiary of the old Marland Oil Company.

From 1930-34, Parrish was general manager of the Cody Petroleum Company, Cody, Wyoming; he bought Cody Petroleum Company's interest in 1932 and disposed of his interests in 1934 and returned to Dallas, where he organized the Parrish Tool Corporation.

Parrish has spent the years since 1936 with the Mission Manufacturing Company, Houston, Texas. He is the inventor of the Mission Swab and his intimate knowledge of drilling and production in all its phases provided his mechanical skill and inventive ability ample scope for his talents.

B. E. "PLUG" PARRISH

Parrish is survived by his widow and one son, Benjamin Eugene Parrish, Jr.

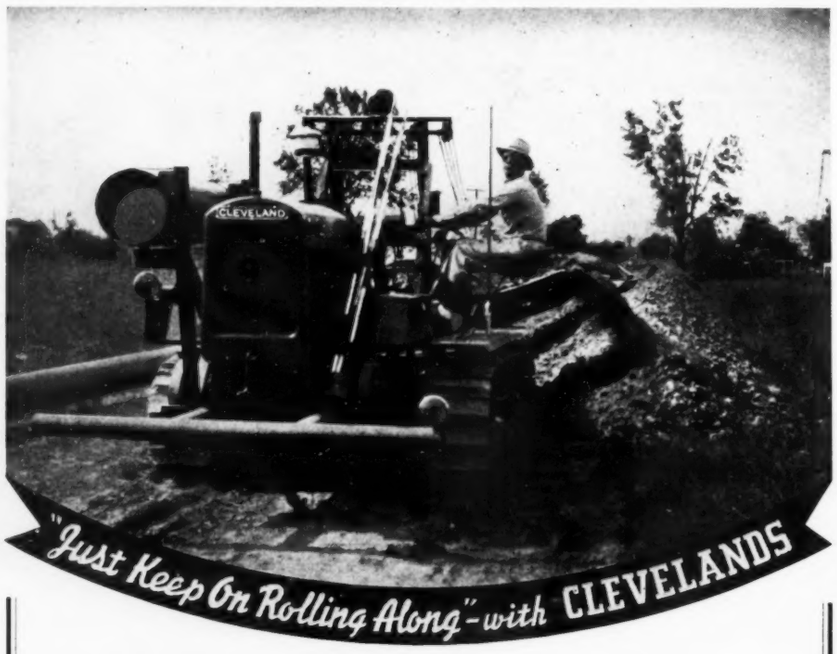
Overbeck Elected Chairman Appalachian Meter School

At the Fourth Annual Appalachian Gas Measurement Short Course, held recently at the School of Mines, West Virginia University, Morgantown, West Virginia, J. E. Overbeck of the Columbia Engineering Corporation, Columbus, Ohio, was elected chairman of the school for the coming year.

J. E. OVERBECK

Overbeck is well known to members of the gas fraternity and, under his energetic leadership, it is expected that the 1942 school will continue the steady growth that has characterized each previous meeting.

The Appalachian Gas Measurement Short Course is the only one of its kind in the Eastern United States. The 1941 meeting attracted 416 registrants, representing 29 states, the District of Columbia, and the Dominion of Canada. Employees of 27 manufacturing companies, 74 gas utilities, and 6 public service commissions comprised the attendance. The interest in the papers read and discussed proved that the theme of the course, "Theory and Practice of the Measurment of Gases," is a subject that commands the attention of the entire gas industry. In addition to the prepared papers and formal proceedings, the numerous and unreported seminar sessions throughout the three-day meeting were of utmost interest and value to those attending.



CLEVELANDS Keep Your Job Moving Because . . .

In Clevelands, correct design joins hands with "tops" in Quality to produce machines that are definitely leaders in Performance. Power and traction to take them anywhere are coupled with the ultimate in strong, long wearing material. Thus, not only mere repair costs but the even more serious service-interruptions are brought to a minimum. These are user-substantiated facts that help tell the story of why Clevelands' continuity of performance pays you big dividends in resultant cost-savings.

• • •

THE CLEVELAND TRENCHER COMPANY
20100 ST. CLAIR AVE. "Pioneer of the Small Trencher" CLEVELAND, OHIO
"CLEVELANDS" Save More . . . Because they Do More

Harry E. Hester with McCullough Tool Company

Harry E. Hester, for the last 5 years head of the service department of Mediearis Oilwell Supply Company, is now on the sales staff of McCullough Tool

HARRY E. HESTER

Company. Hester will work out of the main California office in Los Angeles, largely confining his activities to the Basin areas, at least for the present.

Herbert Henderson Elected Gulf Vice-President

Herbert Henderson, general manager of the Gulf Oil Corporation's Engineering Department, Pittsburgh, Pennsylvania, has been elected vice-president in charge of engineering of both the Gulf Oil Corporation and the Gulf Refining Company.

HERBERT HENDERSON

Joining the Gulf Companies in 1907, Henderson organized the company's engineering department at Port Arthur, Texas. During 1928, this department was transferred to Pittsburgh, and Henderson continued in charge.

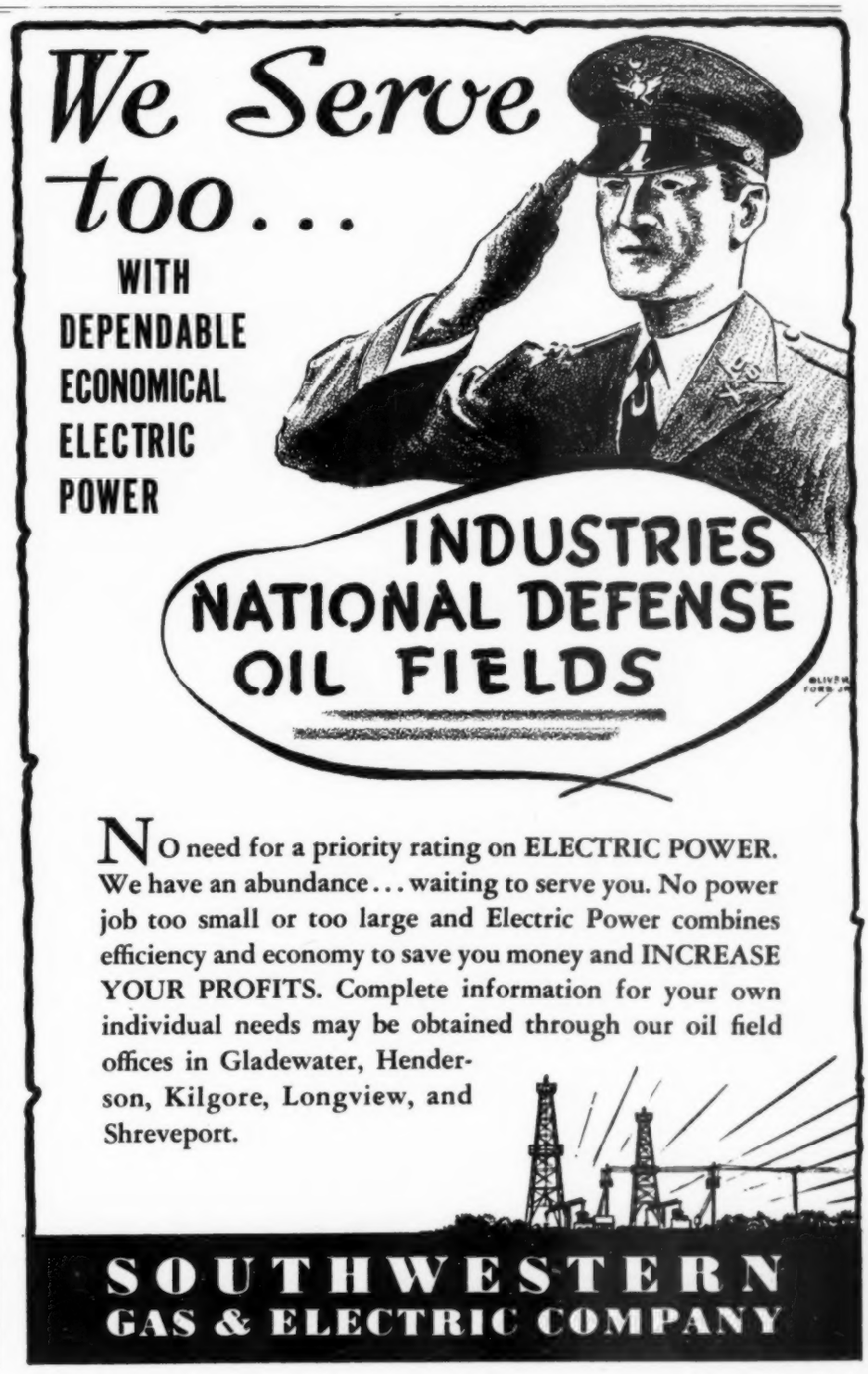
Henderson's election to the Gulf vice-presidency was announced following the regular meeting of the board of directors.

William G. Hamilton Promoted

American Meter Company has announced the recent promotion of William G. Hamilton, Jr., to the position of assistant manager of the Philadelphia factory and sales territory.

After formal education at Penn Charter Academy and Swarthmore College, Hamilton joined the organization December 1, 1927, with the Helme and McIlhenny factory, which some years ago was consolidated with the John J. Griffin and Company factory into American Meter Company, Philadelphia. Since then he has applied himself extensively with great success particularly in the fields of pressure regulation, flow measurement and flow control, and will continue to specialize on this important phase of the company's engineering service.

WILLIAM G. HAMILTON, JR.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WITH DEPENDABLE ECONOMICAL ELECTRIC POWER
INDUSTRIES
NATIONAL DEFENSE
OIL FIELDS
NO need for a priority rating on ELECTRIC POWER. We have an abundance... waiting to serve you. No power job too small or too large and Electric Power combines efficiency and economy to save you money and INCREASE YOUR PROFITS. Complete information for your own individual needs may be obtained through our oil field offices in Gladewater, Henderson, Kilgore, Longview, and Shreveport.
SOUTHWESTERN
GAS & ELECTRIC COMPANY

Vinson Supply Company Opens New Store

Opening of Vinson Supply Company's store at Odessa, Texas, to serve the West Texas and New Mexico areas, has been announced. The store is housed in a new 30-ft. by 60-ft. building, a front view of which is pictured herewith. Besides having ample warehouse space, the building also includes an attractive office and living quarters for the warehousemen.

This new store has been placed at Odessa for the primary purpose of warehousing Fisher control equipment as required for production work in that area.

Louis Barnett, a thoroughly trained control engineer, is the Vinson sales representative in the West Texas and New Mexico territory. He is in full charge of the new Odessa store. Robert Searls is the warehouseman in control of stocks and shipments.

The store is at 912 North Grant Street, Odessa.

Long Lived
Red Seal Engines
A
PROFITABLE
INVESTMENT

JUST OFF THE PRESS

New Loose Leaf Oil Field Catalog gives complete information on all models . . . .

All information is easy to find. Your copy is ready. Please write for it on your business letterhead.

Enclosed Units, like the above, are made covering a 5 to 100 Horse Power range. They are built to withstand all weather conditions and side panels may be locked for complete protection.

Keeping Pace with Defense — Keeping Faith with Customers

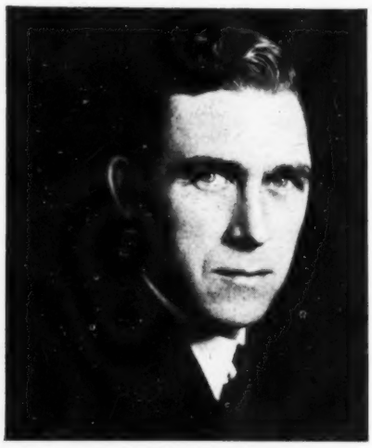
Sales and Service Facilities

Dallas: National Welding & Grinding Co. *Longview:* Standard Tool & Machine Co.
Houston: C. Jim Stewart & Stevenson Co. *Wichita Falls:* Wichtex Machinery Co.

Continental Motors Corporation
MUSKEGON, MICHIGAN

American Meter Appoints Dushane Manager Mid-West Territory

At a recent meeting of the board of directors of American Meter Company, C. B. Dushane, Jr., was advanced to the managership of the Mid-West territory.



C. B. DUSHANE, JR.

This promotion came in recognition of Dushane's 21 years in American Meter Company service. In 1920 he left the Naval Aviation service, where as pilot he had flown abroad in 1917-1919, and became associated with the Maryland Meter Works division of the company, subsequently being transferred to the Chicago office. He successively occupied the positions of representative, engineer, and assistant manager.

Bethlehem Opens New Store

Bethlehem Supply Company, Tulsa, Oklahoma, has recently completed a new store building at Harvey, Louisiana. The personnel consists of T. H. Salter, district manager; Roy Maness, store manager and field salesman, and E. C. Dorroh, assistant store manager.

Houston Nomads Resume Meetings

The Houston Chapter of Nomads resumed activities October 27 with a meeting at the River Oaks Country Club. The chapter had been recessed for three months during the summer.

Speakers at the meeting were Bert Childs, vice-president of Reed Roller Bit Company, and Ray L. Dudley, president of Gulf Publishing Company.

Fred R. Lowell Killed In Plane Crash

The National Supply Company announces with regret the passing of Fred R. Lowell, manager of engine sales.

FRED R. LOWELL

Lowell was a passenger on the plane of the Northwest Airlines enroute to Seattle, Washington, which crashed near Fargo on October 30.

Lowell was affiliated with The National Supply Company organization in April, 1936, when he assumed charge of the company's commercial engine sales in the Southwest with headquarters at Houston, Texas. In January, 1940, he was transferred to Springfield, Ohio, to become manager of oil-field engine sales and occupied this position at the time of his death.

After his graduation from the University of Wisconsin in engineering in 1926, Lowell became associated with the Engineering Department of Fairbanks-Morse and Company. In 1928 he joined the engine sales staff at the Chicago office and in June, 1933, became Fairbanks representative to the Philippine Islands in charge of sales and service of all the company's products.

In June, 1933, he was made manager of Export Division Machinery Department of Fairbanks-Morse with headquarters in New York. Lowell resigned this position in April, 1936, to join the National's sales staff.

Franks Manufacturing Observes Tenth Anniversary

A decade of progress—and pioneering—is the accomplishment of the Franks Manufacturing Corporation of Tulsa, Oklahoma, which this year is celebrating its tenth anniversary as manufacturer of portable well-servicing and drilling equipment.

The firm was established in 1930 when the founders, H. H. Franks and Carl White, Jr., introduced the idea of designing and constructing a power take-off that would fit any truck to supply power from the truck motor to hoist or winch servicing units.

The second pioneering step of the firm was the fabrication of a final friction-drive well-servicing winch.

Beginning with these two fundamental ideas, Franks has continued to pioneer throughout a decade that has seen the development by the firm of such equipment as "slim-hole" portable rotary drilling units mounted on trucks and capable of drilling to 5000 ft.; the "open face" portable telescoping derrick servicing unit with a 54-ft. over-the-road length and a 90-ft. height when fully telescoped to permit the stacking of doubles, for servicing to 10,000 ft.; and a convertible "open face" derrick, skid-mounted, for drilling to 8500 ft.

Prime objective in each of these steps has been to produce equipment that would afford the fastest rig-up, tear-down, and location-to-location moving. In addition to providing for large savings in time and labor, Franks equipment has been designed and built for savings in water, fuel, moving, and casing, through the use of smaller holes, as well as other economies.

Franks Manufacturing Corporation helped meet the need for a light but strong equipment by drafting aircraft engineers to design equipment to incorporate a basic principle of airplane construction—strength with minimum weight.

Other equipment also had to be developed and introduced to produce the completely unitized rigs that the firm has designed: a propeller-shaft drive rotary table had to be built; a shorter swivel; every possible "short-cut" to conserve on the valuable space in a portable unit had to be devised.

Save Up to 80%

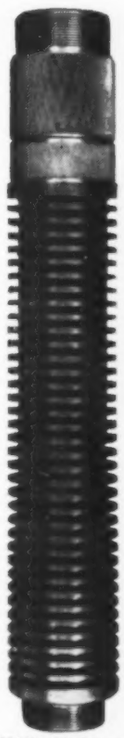
On Pump Repairs and Pulling Expense

Use Long-Life MARTIN PLUNGER

With Replaceable Packing Rings

These Martin rings take all the wear, and one set will far outlast any other type of wearing surface. The Martin plunger body, being smaller than the barrel, is therefore not subject to wear and can be used over and over indefinitely. Changing Martin rings is as easy and simple as changing the blade in your safety razor.

Tube life is generally increased two to five times. The grinding action of sandy fluid is greatly reduced because of the resilience of the Martin rubber and fabric rings. Furthermore, there is no lack of lubrication even when pumping 100% salt water. Water lubricates rubber.



3¾" x 36 Groove Martin Plunger Body Without Rings.

Conserve with MARTIN PLUNGERS

***Only* MARTIN PLUNGERS have the One-Piece *"Fluid Proof"* Bodies and "compensated" precision packing rings.**

Write for Illustrated Catalog or see Composite Catalog, Page 1619

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Manufacturer
11 W. Brady St. Tulsa, Okla.

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Hugh Robinson, Blackwell, Okla.
Claude Wilmeth, Kilgore, Texas
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SAID THE VICE PRESIDENT

"We have been using Sand-Banum in our boilers for the past two years.

"The Boiler Inspector reported on his last inspection that the boilers were entirely free of scale and in the best condition he had found them."

"The Entirely Different Boiler and Engine Treatment"

SAND-BANUM comes in the handy 16 oz. can ready for instant use. Just apply a few ounces weekly. One 16 oz. can safeguards one 250 hp. boiler for one month.

AMERICAN SAND-BANUM COMPANY, Inc.

9 Rockefeller Plaza
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Stocks carried by
WESTERN SAND-BANUM COMPANY
Houston, Texas **Fresno, California**
and at other convenient points including leading supply houses

•

Export Representatives
PETROLEUM MACHINERY CORP.
30 Rockefeller Plaza **New York City**

Wellhead Equipment Makers Perfect Trade Association

Organization of an "Association of Well Head Equipment Manufacturers" has been perfected with G. S. Watson, McEvoy Company, Houston, Texas, president; E. L. Lorehn, Cameron Iron Works, Houston, vice-president, and A. J. Penick, Oil Center Tool Company, Houston, secretary-treasurer. The officers, with L. L. Rector, Rector Well Equipment Company, Fort Worth, Texas, and Herman B. Hendershot, Hinderliter Tool Company, Tulsa, Oklahoma, comprise the board of directors. L. D. Hilton, who has been active in wellhead equipment manufacturing circles for many years, is executive secretary, with headquarters in Houston.

Seated, left to right: E. L. Barker, Atlas Engineering Company, Houston; L. D. Hilton, executive secretary of the association, Houston; E. L. Lorehn, Cameron Iron Works, Houston; G. S. Watson, McEvoy Company, Houston; L. L. Rector, Rector Well Equipment Company, Fort Worth; B. V. Fisher, Oil Center Tool Company, Houston.

Standing, left to right: Charles Zartman, Rector Well Equipment Company, Fort Worth; C. L. Cron, Rector Well Equipment Company, Houston; John H. Moran, Hinderliter Tool Company, Houston; J. J. Hastik, Brown Oil Tool Company, Houston; Frank Crow, Cameron Iron Works, Houston; L. L. McColum, Hinderliter Tool Company, Fort Worth; C. J. Harris, Beaumont Iron Works, Houston; M. T. Works, Cameron Iron Works, Houston; Roy Hammond, Lone Star Tool Company, Wichita Falls; A. Henderson, McEvoy Company, Houston; R. V. Evridge, Rector Well Equipment Company, Fort Worth.

Purpose of the association, a non-profit organization, is "to acquire, preserve, and disseminate valuable business information and to adopt rules and standards of classification in equipment where standards and classifications are required and generally to promote the interests and trade and increase the facilities of commercial transactions relating to wellhead equipment business."

Five specific objectives have been undertaken, as follows:

1. Establish a system of certified pressure testing for various equipment.
2. Standardization of equipment, with the adoption of a code of standards and ethics.
3. Priorities.
4. Consideration of service, liabilities, wages and hours.
5. Improvement of supply store relations.

Committees for each of these objectives have been chosen.

Regular meetings will be held the second Tuesday in each month. Election of officers will be held the second Tuesday each March.

This association achieved one of its purposes at a monthly meeting held in Fort Worth recently, when it approved the committees recommendation on the nomenclature section of objective No. 2 (standardization) and adopted specific names for equipment and units manufactured by the group.

Robert Grant Joins Young Radiator Company

Robert Grant has joined Young Radiator Company of Racine, Wisconsin, in a production and managerial capacity, according to an announcement by Fred M. Young, president.

ROBERT GRANT

Grant was educated at Cornell University, is a member of the Society of Automotive Engineers, and received his early production training as a line superintendent for the Nash Motors Division of Nash-Kelvinator Corporation at Kenosha and Racine, Wisconsin. He later served as executive vice-president of the Fuller-Johnson Corporation, Detroit, Michigan; and its subsidiaries—Good Roads Machinery Corporation, Kennett Square, Pennsylvania, and American Electric Switch Company, Minerva, Ohio. Grant leaves this position to go with Young Radiator Co.

West Virginia School of Mines Employs Oil and Gas Instructor

The School of Mines of West Virginia University announces the appointment of Robert F. Davisson of Grafton and Charleston, West Virginia, as instructor in oil and gas engineering. Davisson was a graduate of the School of Mines in the oil and gas option in the class of 1939. Since that time he has been employed with the Pittsburgh Equitable Meter Company in investigating and test work on gas measurement meters and regulators. Davisson goes to the university from the West Virginia Public Service Commission where he has been employed for the last year and a half as a field gas engineer. He is widely known throughout the oil and gas industry of the state, and has a background that should particularly fit him into the work of training young men for the oil and gas industry of West Virginia as well as doing investigating work on some of the problems of the industry.

The appointment of Davisson, together with the completion of the new Mineral Industries Building in the near future, will enable the School of Mines to offer improved instruction in its oil and gas curriculum as well as to expand considerably the investigation and research work relating to the industry. The Mineral Industries Building will be equipped with the latest laboratory apparatus for use in oil and gas instruction and research.

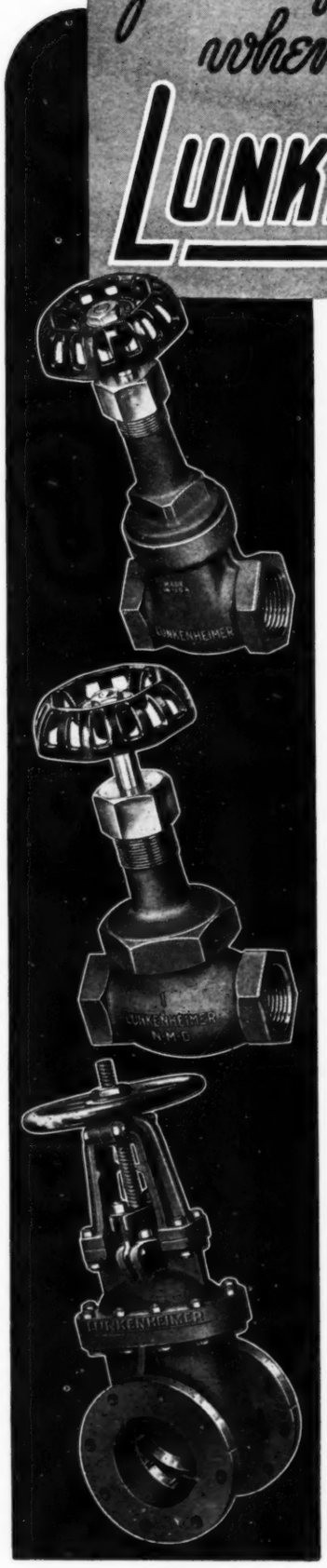
D. R. Yarnall Receives Hoover Medal

Announcement has been made that D. Robert Yarnall, mechanical engineer of Philadelphia, Pennsylvania, has been selected as the fifth recipient of the Hoover Medal, which will be presented during the annual meeting of The American Society of Mechanical Engineers in New York City, December 1-5, 1941.

The Hoover Medal is administered by the Hoover Medal Board of Award, consisting of representatives of the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. It was formally instituted on April 8, 1930, during the celebration of the fiftieth anniversary of The American Society of Mechanical Engineers, to commemorate the civic and humanitarian achievements of Herbert Hoover and to whom the first award was made.

You buy fewer valves when you buy

LUNKENHEIMER



Why? Because Lunkenheimer construction features minimize wear and insure longer service life with less maintenance.

The use of non-corrodible alloys at vital points—design and construction that eliminate excessive wear of working parts—thorough, scientific tests of every valve before shipment—are features of Lunkenheimer Valves that make for longer life, fewer repairs, continuity of service, and lower costs.

Actually you need fewer valves when you use Lunkenheimer because they give you less trouble and stay in service longer. This is extremely important now when virtually all materials have become increasingly necessary to defense activities. You can help conserve these needed materials—insure valve satisfaction — buy fewer valves . . . by specifying Lunkenheimer.

Your Lunkenheimer distributor is cooperating in every way to give you the kind of service you so vitally need for the National Defense program. His facilities will save you time and trouble.

ESTABLISHED 1862
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UNDER CONTROL

Ludlow Double-Disc Gate Valves in operation on a Texas pipe line.

Our vast network of pipe lines is an important asset—more than ever vital to our national well-being.

Ludlow Double-Disc Gate Valves play an important part in pipe line operations. At all times—under gruelling operating conditions and high pressures—they keep things under control. Write for specifications and prices. There's a Ludlow valve available for any standard purpose and we design and build valves for special applications.

The Ludlow Principle of valve construction—parallel seat double-disc gate type—has been universally accepted and preferred for oil, gas, and water lines since 1866.

The LUDLOW VALVE MFG·CO·INC· TROY·N·Y· SINCE 1866

Haislmaier Promoted By Young Radiator Company

George J. Haislmaier has been appointed sales manager of the Contract Products Division of Young Radiator Company here, according to an announcement by J. J. Hilt, vice-president.

GEO. J. HAISLMAIER

Haislmaier, a graduate of Marquette University College of Engineering, has been with Young Radiator Company since 1936 and until his most recent promotion, had served as assistant sales manager and government specification engineer of the company's Contract Division, which includes the manufacture of heat exchangers, automotive radiators, jacket water coolers, and other types of heat transfer products for transportation, industrial, and military purposes. After his graduation, Haislmaier spent several years in civil engineering and construction work before joining the Young Radiator sales department.

Hilt, who has been serving as Contract Division Sales Manager, in addition to his duties as vice-president, will now devote his entire time to the further development and coördination of the rapidly increasing volume of contract work being handled by the company for military and defense needs.

San Joaquin Valley Chapter A.P.I. Meets

A regular meeting of the San Joaquin Valley Chapter of A.P.I. was held at Bakersfield, California, October 21.

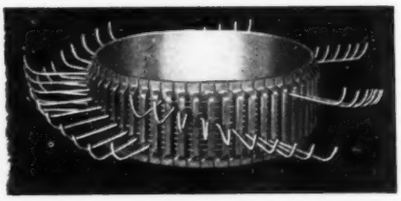
Paul Howard announced plans for organization of a San Joaquin Valley Section of A.I.M.E. and invited participation on the evening of October 27 at the Hotel El Tejon.

Speakers of the evening were:

Mel Chun, Lane-Wells Company, Los Angeles, who described the background, development, and operation of the gamma ray in a paper entitled "Radioactivity Well-Logging Through Casing."

E. W. McAllister, Western Gulf Oil Company, Bakersfield, whose "Discussion of Paloma Field," dealt interestingly with the unusual problems of that area.

Frank Hornkohl, Hornkohl Laboratories, Bakersfield, who showed movies of a Mexican holiday, taken by Howard Nichols.



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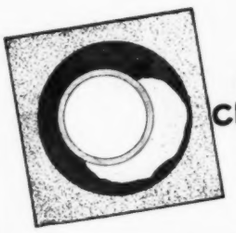
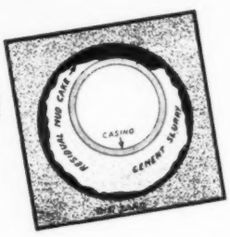
WALL CLEANING GUIDES

Patents Applied For

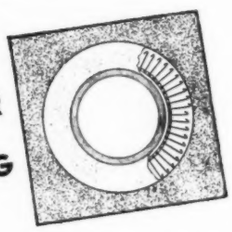


PREVENT CHANNELING

REMOVE MUD CAKE



CENTER THE CASING



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HOUSTON, TEXAS

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Lane-Wells Sales Meeting

During the recent meeting of the A.I.M.E. in Dallas, Texas, the Lane-Wells Company organization took the occasion to hold a sales meeting. In the photograph, left to right, front row, are: M. E. Montrose and Rodney S. Durkee, both of Los Angeles, California. Back row, left to right, are: W. J. Jackson, Dallas, Texas; Morton Higgs, Houston, Texas; James D. Hughes, Houston; R. B. McCullar, Oklahoma City, Oklahoma, and J. C. Barcklow, Oklahoma City.

Petroleum Electric Power Association To Meet December 4 and 5

One of the high points of the 13th annual conference of the Petroleum Electric Power Association, when it meets December 4 and 5 at the Baker Hotel in Dallas, Texas, will be an enlightening talk by Don Knowlton, Phillips Petroleum Company, Bartlesville, Oklahoma, on "The Future of Oil Production Viewed from the Standpoint of Present-Day Production Methods."

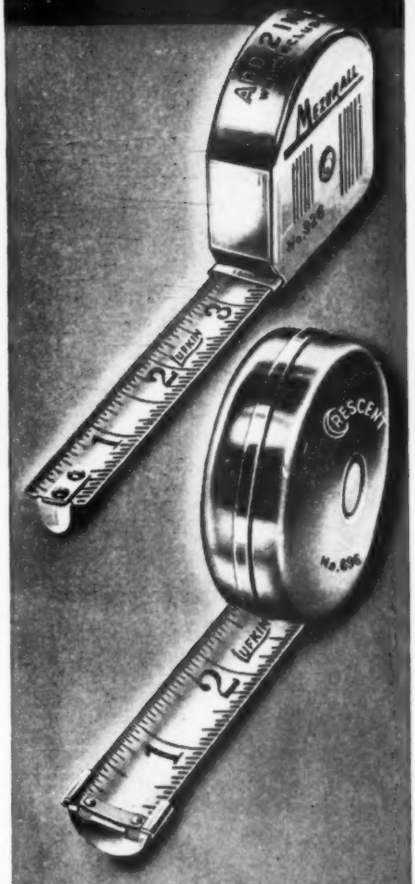
The meeting, expected to attract more than 200 sales engineers and other executives from utility electric power companies from New York, New York, to Corpus Christi, Texas, is scheduled for a full two days' discussion of timely important topics concerning utility electric power and the petroleum industry.

In addition to Knowlton's paper, talks during the first day sessions will include those of Dave Levy and E. A. Koenig, Magnolia Pipe Line Company, Dallas; K. R. Albert, Louis Allis Company, Dallas; C. G. Unlaub, Electric Machinery Company, Dallas, all speaking on "Variable Speed Couplings and Variable Capacity Pumps;" H. C. Gear, Lone Star Gas Company, Dallas, will bring "A Message From the Petroleum Industry Electrical Association," and Robert Haldane, Shell Oil Company, Dallas, will speak on "Changes in Refinery Electric and Steam Requirements Resulting from the Manufacture of Synthetic Rubber and Explosives."

Papers the second day will include those of B. J. Martin, publisher, *Electrified Industry*, Chicago, speaking on "New Uses of Electric Service;" G. R. Prout, manager, Industrial Control Department, General Electric Company, Schenectady, New York, will have a worthwhile message on "Supplying Defense Needs;" and E. A. Armstrong, Public Service Company of Northern Illinois, Chicago, will tell "How Electric Utilities Have Met the Demand for Power."

Election of officers, directors, and committeemen for 1942 will round out the last session. Present officers of the Petroleum Electric Power Association are: E. L. Robinson, Gulf States Utilities Company, president; H. E. Roberts, The Empire District Electric Company, vice-president; and K. K. Kreamer, Houston Lighting and Power Company, secretary-treasurer.

SAVE TIME WITH
LUFKIN
TAPE-RULES



Every busy oilman needs a Tape-Rule for his vest pocket —where it's handy and ready for those dozens of little measuring jobs that come up every day. There's no need wasting time to search for a tape or in trying to guess the measurement. Just reach in your pocket for your "Mezurall" or "Crescent." Your dealer can help you select the one you need.

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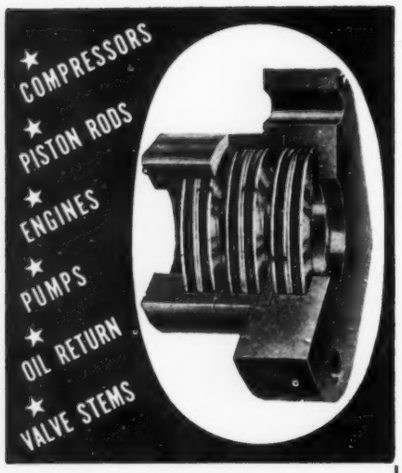
SAGINAW, MICHIGAN • New York City
TAPES · RULES · PRECISION TOOLS



STAR PERFORMANCE in Any Packing Job

For nearly half a century, France "Full-floating" Metal Packing has been used the world over for sealing piston rods in any type of reciprocating engine, pump or compressor as well as valve stems, whether reciprocating or oscillating. A design can also be furnished to prevent crankcase oil leakage and the combined service of preventing crankcase oil leakage and condensation from entering the crankcase.

For star performance (maximum sealing efficiency with minimum maintenance expense), specify France "Full-floating" Metal Packing — the packing that L-A-S-T-S.

Original FRANCE Metal Packing — Sold on approval — Satisfaction Guaranteed

Catalog M-3 tells the complete story. Write for it.

THE FRANCE PACKING COMPANY
Tacony Philadelphia Penna.
Mid-Continent Representative:
Mr. J. M. FULLER, 3725 W. 7th Street
FORT WORTH, TEXAS

Original FRANCE METAL PACKING

W. R. Boyd, Jr., Heads American Petroleum Institute

William R. Boyd, Jr., was reëlected president of the American Petroleum Institute at a meeting of the board of directors on November 6 in San Francisco, California. The board abolished

WILLIAM R. BOYD, JR.

the offices of executive vice-president and assistant secretary, and reëelected all other officers. Boyd was executive vice-president from 1929 until his election several weeks ago to fill the unexpired term of the late Axtell J. Byles as president.

Other officers reëlected were: George A. Hill, Jr., Houston Oil Company of Texas, Houston, Texas, vice-president for production; J. Howard Pew, Sun Oil Company, Philadelphia, Pennsylvania, vice-president for refining; Eric V. Weber, Eureka Oil Company, Cincinnati, Ohio, vice-president for marketing; O. D. Donnell, The Ohio Oil Company, Findlay, Ohio, treasurer, and Lacey Walker, American Petroleum Institute, New York, New York, secretary and assistant treasurer.

The executive committee for 1942 is as follows: W. R. Boyd, Jr., American Petroleum Institute, New York; J. A. Brown, Socony-Vacuum Oil Company, Inc., New York; Robert H. Colley, The Atlantic Refining Company, Philadelphia; H. D. Collier, Standard Oil Company of California, San Francisco; Henry M. Dawes, The Pure Oil Company, Chicago, Illinois; O. D. Donnell, The Ohio Oil Company, Findlay, Ohio; W. S. Farish, Standard Oil Company (New Jersey), New York; Jake L. Hamon, Cox and Hamon, Dallas, Texas; George A. Hill, Jr., Houston Oil Company of Texas, Houston; William F. Humphrey, Tide Water Associated Oil Company, San Francisco; R. C. Hunter, Mid-Continent Oil and Gas Association, Abilene, Texas; W. A. Jones, Cities Service Company, New York; F. A. Leovy, Gulf Oil Corporation, Pittsburgh, Pennsylvania; B. L. Majowski, Deep Rock Oil Corporation, Chicago; J. Howard Pew, Sun Oil Company, Philadelphia; Frank Phillips, Phillips Petroleum Company, Bartlesville, Oklahoma; Charles F. Roeser, Roeser and Pendleton, Fort Worth, Texas; W. S. S. Rodgers, The Texas Company, New York; E. G. Seubert, Standard Oil Company (Indiana) Chicago; H. F. Sinclair, Consolidated Oil Corporation, New York; W. G. Skelly, Skelly Oil Company, Tulsa, Oklahoma; Rees H. Taylor, Union Oil Company of California, Los Angeles, California; R. G. A. van der Woude, Shell Union Oil Corporation, New York, and E. V. Weber, Eureka Oil Company, Cincinnati.

W. C. Whaley General Manager in California for Barnsdall

W. C. Whaley, who succeeded R. A. Broomfield as general manager of California operations of Barnsdall Oil Company on November 1, is a native Californian, born in Santa Maria on April 29, 1894, whose first job was in the oil fields and who has been working in the oil industry ever since.

W. C. WHALEY

Whaley joined Barnsdall under Fred A. Fortine, as a driller in 1924. During his period of service with the company, he has been drilling foreman, field superintendent, general superintendent, vice-president and general superintendent, and now, with the retirement of Broomfield from active service, vice-president and general manager of California operations. He has been a Barnsdall director since 1940.

A.P.I. To Meet In Chicago

The 1942 annual meeting of the American Petroleum Institute will be held in Chicago, beginning November 9.

The executive committee of the A.P.I. also has announced that the Mid-year Meeting will be held at Oklahoma City, Oklahoma, at a date to be selected later.

Company Refuses Order, Remains Neutral

It is not often that an industrial concern refuses to execute an order for its products, but in this instance it did.

The story comes from Tangier, where two Italian submarines, damaged by British gunfire, had taken refuge. The incident, at one juncture, seemed likely to cause international complications.

It was learned subsequently that the Italians tried every ruse to obtain supplies of the protective solution manufactured by the company, with which to complete their repairs. They sent as their first emissary a Spaniard who had been engaged in the repair work.

The company's agent at Tangier, knowing the Spaniard, asked him for his word of honor that the material would not be used on the Italian vessels. This the Spaniard refused to give, and the two containers of paint solution that he had taken away in his car were returned on the following day.

There followed a procession that had a League of Nations air about it. An Italian of the Tangier Administration came to try and buy the material but was sent away empty-handed. Next came a Frenchman, and finally another Spaniard, but they had no better luck.

The repaired Italian submarines eventually departed—minus their protective coating of paint.

This is only one example of the splendid manner in which alert foreign representatives of American manufacturers are helping avoid international entanglements. (Based on an item appearing in *Bitumastic Bulletin*.)

F. W. Rowe, of Johns-Manville, Retires

Frank W. Rowe, general purchasing agent of Johns-Manville Corporation for 23 years, is among the first to retire under the company's new retirement plan, it is announced. Rowe's retirement was announced with those of 11 other veteran employees in plants and offices throughout the country.

Since the plan went into effect July 1 of this year, 96 percent of Johns-Manville employees eligible to participate have signed up. The plan is voluntary and provides for a retirement income at the age of 65 for all employees on the regular payroll two or more years who sign up, regardless of what they earn per year. Under the plan, employees who have had ten or more years' service are also entitled to consideration for retirement at any time they become permanently incapacitated.

Look for the Arm and Hammer

ARMSTRONG BROS.

STUB END WRENCHES

These extra heavy, ruggedly designed Chrome Vanadium Steel Wrenches take long tubular slip-over handles, stand up to long leverage . . . tighten screws, bolts and nuts far tighter or loosen them even when badly corroded. These are ideal wrenches around rigs, pipe lines and for general heavy duty work. Three types (from 1¼" to 3½") with long hollow tubular steel handles, each of which fits several sizes.

"The Tool Holder People"
331 N. Francisco Ave., Chicago, U. S. A.

To Help You Cut that 83% Lost Workers' Time

. . . caused by infection!

Free

Leaflet describes first aid plans that have proved effective and economical in small, medium and large plants, with the aid of properly designed and equipped kits and signs.

8-12

Send me booklet: "A Unit First Aid Plan that Keeps Skilled Men Working."

E. D. BULLARD COMPANY
275 Eighth St., San Francisco

Everything BULLARD for Safety

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NATIONWIDE SALES AND STOCKS

Renew Your Subcription Promptly

PROPERLY CONDITIONED MUD IS HALF THE BATTLE WON

Link-Belt vibrating mud screens, such as the dual hook-up of 24" x 48" units pictured here in action on a South Texas lease, are serving as first line defense equipment in the battle against blowouts — keeping the mud properly reconditioned, properly weighted, readily pumpable. Link-Belt introduced the vibrating screen to the oil fields, pioneered it, and has constantly improved it.

LINK-BELT COMPANY

Philadelphia • Houston • Dallas
Los Angeles • New York • Toronto
Sold by Most Supply Houses

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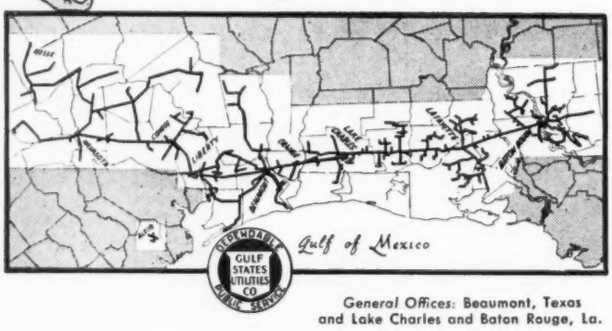
LINK-BELT MUD SCREEN
THE VIBRATING SCREEN THAT HAS EVERYTHING

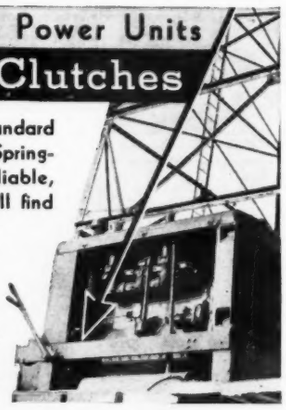
NO ROOKIE-

Gulf States Is Ready!



General Offices: Beaumont, Texas and Lake Charles and Baton Rouge, La.

The Most Effective Power Units *Use* Rockford Clutches



Built in a complete range of standard sizes, Rockford Over-Center and Spring-Loaded Clutches are notably reliable, efficient, economical . . . you'll find them in leading makes of power units, tractors and producing equipment.

When your power units have Rockford Clutches; you get quick-acting, smooth, long-lasting transmission control that delivers power most effectively under all conditions.

Rockford Over-Center Clutches lock in or out of engagement with easy, powerful roller cam action; Spring-Loaded types work like automobile clutches. Rockford Power Take-Offs fit S.A.E. flywheel housings, take any type of plate clutch. Investigate. Specify Rockford Clutches when purchasing.

Rockford Over-Center Clutch

Rockford Power Take-Off

Rockford Spring-Loaded Clutch

FREE Engineering Service

Designers are invited to consult our engineers freely, without obligation, for developing Rockford Clutch applications. Write, now.

ROCKFORD DRILLING MACHINE DIVISION

Borg-Warner Corporation

1303 Eighteenth Avenue, ROCKFORD, ILLINOIS, U. S. A.

Over-Center Clutches • Spring-Loaded Clutches • Power Take-Offs

TRADE LITERATURE

What to Write For

A NEW ILLUSTRATED catalog No. 701 issued by The Louis Allis Company, Milwaukee, Wisconsin, completely describes the Louis Allis induction-type motors. The 20-page descriptive bulletin 508E contains the latest developments on the Louis Allis explosion-proof motors. Readers are asked to write for their free copy.

CRANE COMPANY, 836 South Michigan Avenue, Chicago, Illinois, will send without obligation, copies of their bulletins aimed to assist in obtaining better service from piping equipment. Three bulletins have been released to date on proper installation methods, pointers on correct piping placement, and guides in valve selection and usage.

FULL INFORMATION on "National' Carbon Raschig Rings used in sweetening natural gas and other petroleum products is contained in a bulletin setting forth the advantages of Raschig Rings. Address the National Carbon Company, Inc., Cleveland, Ohio, for a copy.

CATALOG M-3 tells the complete story of the France "Full-floating" metal packing used for sealing piston rods in any type of reciprocating engine, pump, or compressor. Address The France Packing Company, Philadelphia, Pennsylvania, for your copy.

ADVANTAGES AND BENEFITS derived from the use of Fulton valves are contained in descriptive Bulletin 3259. Write the Chaplin-Fulton Manufacturing Company, 38 Penn Avenue, Pittsburgh, Pennsylvania.

A LEAFLET describing first aid plans that have proved effective and economical in small, medium, and large plants, with the aid of properly designed and equipped kits and signs, is entitled "A Unit First Aid Plan That Keeps Skilled Men Working." Write E. D. Bullard Company, 275 Eighth Street, San Francisco, California, for a free copy.

WRITE FOR descriptive literature on all types of American Air Filters for engine and compressor protection to the American Air Filter Company, Inc., 19 Central Avenue, Louisville, Kentucky, manufacturers of a complete line of filters for every air cleaning need. Write for Cycoil Bulletin No. 130D.

FLUID PACKED PUMP COMPANY, Los Nietos, California, will send upon request the new Catalog No. 9 giving full information on the correct Flupaco pump for all wells.

B AND W, INC., will send free their Bulletin 102 concerning the B and W wall cleaning guides if requested. Address B and W, Inc., 1105 Commerce Building, Houston, Texas, or 3545 Cedar Avenue, Long Beach, California.

LEEDS AND NORTHRUP COMPANY, 4901 Stenton Avenue, Philadelphia, Pennsylvania, is releasing Bulletin N-96-702(A) to those interested, describing for the first time equipment that enables a refinery operator to "see" the pH of dehydrator water simply by glancing at the indicating scale of a Micromax recorder. Write for a copy of the bulletin.

"8-EXTRA PROFIT-MAKING FACILITIES" is the title of the new 4-page folder being released by R. G. LeTourneau, Inc., Peoria, Illinois, and Stockton, California. This folder introduces two new LeTourneau products, preformed Tournarope and Tournaweld electrodes. Your copy will be sent on request.

THE PROPERTIES of refractory insulating concrete are described in a new bulletin giving detailed information on this cold-setting, monolithic, refractory material using special types of refractory concrete light-weight insulating aggregates. Six charts give hot- and cold-face temperatures and heat loss for different thicknesses of several types of furnace walls at operating temperatures from 250° to 2500°F. Address the Atlas Lumnite Cement Company, Chrysler Building, New York, New York, for your copy.

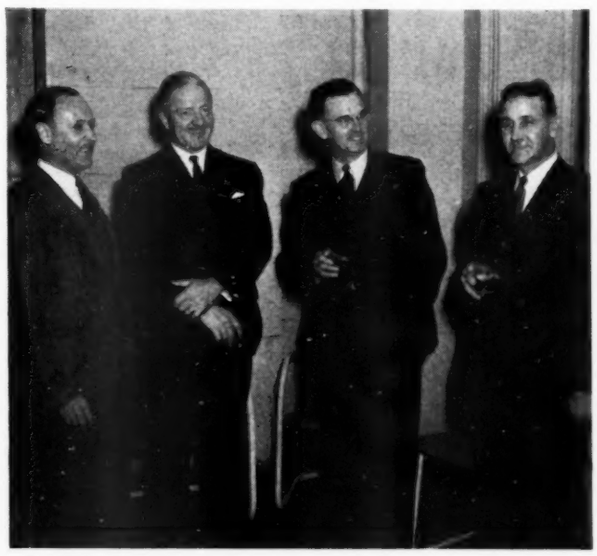
A NEW BOOKLET, "Air Reduction—A Quarter Century of Progress," is being released to give a quick overall picture of the products produced by Air Reduction Sales Company and its subsidiary companies and the use of these products in industry and defense. A copy will be sent on request. Address Air Reduction Sales Company, Lincoln Building, New York, New York.

THE BROWN INSTRUMENT COMPANY, Philadelphia, Pennsylvania, has issued a new Bulletin No. 85-18 entitled "The Brown Triple Function Proportioning Control System (Utilizing the Beck Mechanism)." Copies of this bulletin will be sent on request.

A NEW ILLUSTRATED CATALOG "TAG Recording Instruments for Temperature and Pressure," No. 1210, has been published by C. J. Tagliabue Manufacturing Company, Park and Nostrand Avenues, Brooklyn, New York.

When Good Fellows Get Together at A.P.I.

The Petroleum Engineer's photographer snapped these officials, prominent in petroleum circles, after one of the afternoon group sessions at the A.P.I. convention, in the lobby of



the St. Francis at San Francisco, California. Reading from left to right: Capt. A. E. Higgins, vice-president, and Col. W. F. Rockwell, president, of Merco Nordstrom Valve Company; C. K. Madison, manager of the Houston office of the valve company, and C. A. Dunlap of Humble Oil and Refining Company.

Listen, Mr. Hitler

you've underestimated American fighting tools like this RIDGID wrench

UNCONDITIONAL GUARANTEE
If this Housing ever Breaks or Distorts we will replace it Free
THE RIDGE TOOL CO. ELYRIA, O.

All-alloy heavy-duty. Sizes 6" to 60". . . . Millions in use.

. . . and the men who are using them, too! No fooling—not any more. That criticizing and beefing you heard was just Democracy warming up to the job. Someday, when you resign from your present position, we'll be glad to send you a nice folder telling you all about this RIDGID Pipe Wrench with housing guaranteed not to let workmen down while putting together ships and factories, tanks and shootin'-irons and all the other things America is turning out in quantities that you aren't going to like. . . . We make *good* tools over here—and we know how to use them. *Ask any Supply House!*

THE RIDGE TOOL CO., ELYRIA, OHIO

RIDGID
WORK-SAVING PIPE TOOLS

Effective with Either Pressure Control or Flow Control

The gradual-opening valve here shown is dependable with flow controllers, with instrument-type auxiliary-controlled pressure regulators, and with many other forms of refinery equipment. Has many applications also in other industries. Made for either direct action (closed by diaphragm pressure) or indirect action (opened by diaphragm pressure). Sizes ½ inch up, all with ample diaphragm area to give positive unfailing response. Write for Bulletin 3259.

FULTON V-PORT
Motor Valve

The CHAPLIN-FULTON MFG. CO.

38 PENN AVENUE PITTSBURGH, PA.

DOUBLE FEATURE

Starring

PLOMB

Combination Open End and Box WRENCH

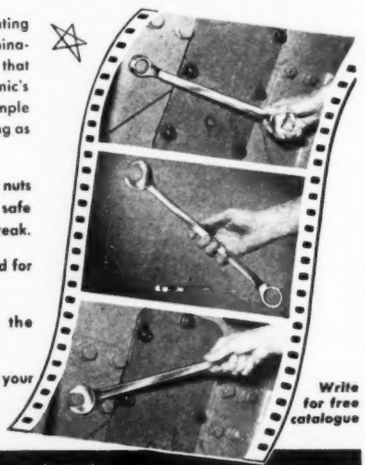
Here's a "motion picture" illustrating two big features of Plomb's combination Open End and Box Wrench that make it a "star" in every mechanic's tool box. The reasons are as simple as A-B-C — the results as satisfying as money in the bank.

★ *First* — Loosen or cinch tough nuts with the offset 12 pt. box end — safe because it won't slip, spread or break.

★ *Second* — Flip the wrench end for end and . . .

★ *Third* — Run the nut with the speedy open end.

You need this star performer in your set. Openings from 5/16" to 1-7/16" — lengths, 3½" to 19"



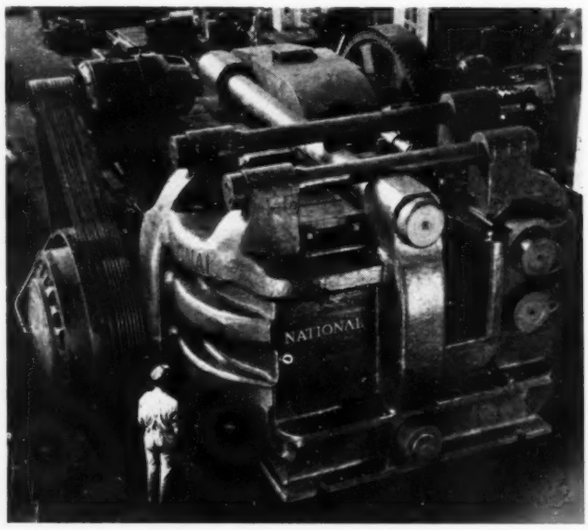
Write for free catalogue

PLOMB TOOL COMPANY
2209 SANTA FE AVE.
LOS ANGELES CALIFORNIA

World's Largest Forging Machine Received by Tube-Turns, Inc.

Widespread attention is being focused on the current delivery of the world's largest forging machines, one in November and the other in February to Tube-Turns, Inc., Louisville, Kentucky, manufacturers of Tube-Turn welding fittings.

Because these mammoth forges represent a far-reaching development in the scope and capacity of forging operations, U. S. industry and defense bodies are keenly interested in their performance at Tube-Turns, Inc. Here they will be put to work immediately in the production of airplane motor cylinder forgings and other vital armament needs included in the defense orders held by this company.



These two huge forges are rated at 9-in. capacity—a feat of designing and construction viewed as impossible a few years ago. Some idea of their size and potentialities may be gained from the accompanying picture. Each machine weighs more than 500,000 lb., and requires well over a year to build. One of the most significant features is the extreme compactness, which can be visualized by considering that the weight of each machine is greater than the combined weight of 140 automobiles.

According to Tube-Turns, Inc., this unique compact design—for a machine of such tremendous size and capacity—insures the exacting accuracy, precision and speed in the forging work for which it will be used.

W. W. Lockwood New Taylor Advertising Manager

Wallace W. Lockwood has been appointed advertising manager of the Taylor Instrument Companies, Rochester, New York, to replace Elmer E. Way, who has resigned.

A graduate of Auburn High School and Syracuse University, Lockwood joined the Taylor advertising department in 1932 and was made assistant advertising manager in 1939.

Pamphlet on Diamond Core Drill Fittings

A pamphlet entitled "Diamond Core Drill Fittings (Third Edition), Commercial Standard CS17-42", which was accepted by the trade as its standard of practice for new production beginning January 1, 1942, is being sent to a limited number of those directly concerned by the U. S. Department of Commerce, National Bureau of Standards, Washington, D. C.

Announcement of the release of the pamphlet was made by I. J. Fairchild, chief of the Division of Trade Standards.

Earl W. Miller Heads Petroleum Equipment Group

At its annual meeting in San Francisco, November 4, the Petroleum Equipment Suppliers Association elected as its president Earl W. Miller of the American Iron and Machine Works Company, Oklahoma City, Oklahoma; Fred F. Murray of the Oil Well Supply Company, Dallas, Texas, as vice-president; and Wharton Weems, Houston, Texas, was reëlected executive secretary and counsel.

EARL W. MILLER

Directors for the coming year were elected as follows:

Eastern District: George H. Alten, Alten's Foundry and Machine Works; Sam Gregg, Bovaird and Seyfang Manufacturing Company; Jene Harper, Franklin Tool Company; O. M. Havekotte, International-Stacey Corporation; Paul H. Jones, The S. M. Jones Company; Donald W. Mackie, Bradford Supply Company; Fred W. Miner, Frick-Reid Supply Corporation; Jerry McJunkin, McJunkin Supply Company; A. W. McKinney, The National Supply Company; F. F. Murray, Oil Well Supply Company; Casper A. Ruf, Parkersburg Rig and Reel Company, and Ferd J. Spang, Spang and Company.

FRED F. MURRAY

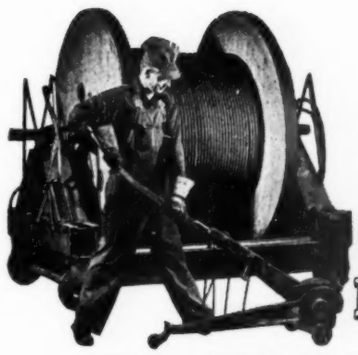
Mid-Continent and Rocky Mountain District: W. M. Bovaird, Bovaird Supply Company; J. R. Brooks, Atlas Supply Company; Frank J. Hinderliter, Hinderliter Tool Company; John J. Larkin, Larkin Packer Company; Earl W. Miller, American Iron and Machine Works Company; A. A. Moody, Jarecki Manufacturing Company; Walter O'Bannon, Walter O'Bannon Company; J. L. Shakely, Frick-Reid Supply Corporation; Guy A. Tompson, Bethlehem Supply Company; Jay P. Walker, National Tank Company, and Carl White, Jr., Franks Manufacturing Corporation.

Southwestern District: W. L. Childs, Reed Roller Bit Company; Ardon B. Judd, Republic Supply Company; H. W. Fletcher, Hughes Tool Company; E. W. Gildart, Norvell-Wilder Supply Company; Allen Guiberson, Guiberson Corporation; Ed L. Lorehn, Cameron Iron Works; W. J. Morris, Continental Supply Company; W. B. Sharp, Mission Manufacturing Company; E. M. Smith, Globe Oil Tools Company; Wallace D. Wilson, Wilson Supply Company; Frank Hereford, Murray-Brooks Hardware Company, and George O'Leary, Houston Oil Field Material Company.

Pacific District: J. C. Axelson, Axelson Manufacturing Company; Markley C. Brown, Hillman-Kelley, Inc.; J. A. Crawford, Youngstown Steel Products Company of California; E. S. Dulin, Byron Jackson Company; D. S. Faulkner, The National Supply Company of California; H. H. Glen, Emsco Derrick and Equipment Company; H. E. Howard, Howard Supply Company; L. H. Keim, Oil Well Supply Company; Rodney S. Durkee, Lane-Wells Company; Roy Somers, Petroleum Equipment Company; Ted Sutter, Baker Oil Tools, Inc., and T. H. Beament, The Republic Supply Company of California.

J. A. O'Brien Elected Vice-President Johns-Manville

The election of John A. O'Brien to the post of vice-president of Johns-Manville Sales Corporation has been announced by Lewis T. Brown, president of the company.



Men Like to Handle UNION-FORMED

Being PRE-FORMED, each wire is relaxed to fit so that it does not unravel when cut from reel even though it is not seized. Being UNION-FORMED, it is easier and safer to handle.

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The "ULTIMATE LOW COST WIRE ROPE"

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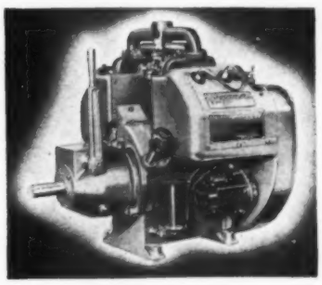
4 cycle 4 cylinder V-type, heavy-duty, air-cooled engine . . . delivers 22 hp. at 2600 R.P.M.



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Draft Horses!

It figures out this way: 22 hp. packed into a 285-lb. heavy-duty engine, or 13 lbs. of compact engine weight for each husky horsepower. That's the sensational Wisconsin VE-4!

Harness this eager, dependable power to your kind of equipment and the kind of work you want it to do.

Write to HARLEY SALES CO., 510 Atlas Bldg., Tulsa, Oklahoma, or M. & M. Bldg., Houston, Texas
Oil Field Distributor for Wisconsin Engines and All Types of Utility Units.

MOST POWER PER POUND
HEAVY-DUTY AIR-COOLED ENGINES

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Milwaukee, Wisconsin, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

HOW CAN FITTINGS, VALVES, BE SALVAGED EASILY AT LOW COST?

ANSWER: "THE SIMPLE OAKITE WAY!" That is what this Western refinery, too, will tell you!

Here... handling salvage work is merely a matter of soaking valves, fittings and parts in a hot solution of a heavy-duty Oakite cleaning material. Heavy deposits of grease, oil and muck are completely removed... without any scraping whatsoever. As a result, many parts formerly discarded are now salvaged easily... restored to good condition for further service. And the cost? Surprisingly low! May we send you details? There is no obligation, so won't you write today?

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Representatives in all Principal Cities of the U. S. and Canada

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MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT

Reading Time for Producers . . .
11 Seconds

Sometimes we are tempted to tell you about reduction gears and bearings and frames and beams and pitmans and counterbalances.

Then we remember that, barrel for barrel, year in and year out, it costs less to pump a well with a JENSEN UNIT. Yes, less than with the method you are now using.

And that, of course, is why we have come to be the largest manufacturer in the world engaged exclusively in the production of pumping equipment.

JENSEN

BROTHERS MANUFACTURING CO.
Coffeyville, Kansas

For detailed JENSEN JACK description and specifications, see . . . **PRODUCING EQUIPMENT DIRECTORY or COMPOSITE CATALOG.**

EXPORT OFFICE: 50 CHURCH STREET, NEW YORK CITY

Reader in South America Suggests Clarification of Formulas

In a recent letter from L. J. van Dijk of The Carribbean Petroleum Company, Maracaibo, Venezuela, he suggests certain additions to the article "Specified Formulas for the Practical Engineer," by Frank R. Young, which appeared in *The Petroleum Engineer*, July, 1941.

In developing the formulas for pressure conversions involving ft. head and lb. per sq. in., Young did not introduce the specific gravity of the fluid, thus making the formulas applicable to all fluids. These general formulas are as follows:

$$\text{Ft. head} \times 0.433 \times \text{sp. gr.} = \text{lb. per sq. in.}$$

$$\frac{\text{Lb. per sq. in.} \times 2.31}{\text{sp. gr.}} = \text{ft. head.}$$

Likewise, the horsepower formula by which energy required to pump fluids is calculated should include specific gravity as follows:

$$\text{hp.} = \frac{\text{gal. per min.} \times \text{ft. head} \times \text{sp. gr.}}{3957}$$

An example is given by van Dijk in which the horsepower required to pump rotary mud is calculated. The mud weighs 85 lb. per cu. ft. and the height it must be lifted is 791 ft. The required volume is 500 g.p.m.

$$\frac{500 \text{ g.p.m.} \times 791 \text{ ft.} \times 1.35 \text{ (sp. gr.)}}{3957} = 134.92 \text{ hp.}$$

It is also suggested that Young should have stressed the fact that 1 hp. = 33,000 ft-lb. *per second*.

N. J. Clarke and A. B. Judd Promoted by Republic

N. J. Clarke, vice-president in charge of sales for Republic Steel Corporation, has been named president of the Republic Supply Company, it is announced by R. J. Wysor, president of Republic Steel. Wysor also announces that A. B. Judd, vice-president, has been elected general manager of the Republic Supply Company.

N. J. CLARKE

Other officers of Republic Supply are: J. H. Brooks, vice-president; J. H. Lollar, Jr., secretary-treasurer, and J. P. Lawrence, assistant secretary-treasurer.

Clarke will continue to make Cleveland, Ohio, his headquarters.

Statement of the Ownership, Management, etc., of THE PETROLEUM ENGINEER October 1, 1941

(This statement is published in compliance with the Act of August 24, 1912.)

Published at Dallas, Texas, monthly August through June, semi-monthly in July.
Publisher: The Petroleum Engineer Publishing Co., Dallas, Texas.
Editor: K. C. Sclater, Dallas, Texas.
Managing Editor: F. H. Love, Dallas, Texas.
Business Manager, W. T. Bryan.
Stockholders holding 1 per cent or more of total amount of stock: C. R. Barrett, W. T. Bryan, T. J. Crowley, W. L. Love, K. C. Sclater, Dallas, Texas.
Known bondholders, mortgagees and other security holders holding 1 per cent or more of the total amount of bonds, mortgages or other securities: None.
W. T. Bryan, Secretary-Treasurer.
Sworn to and subscribed before me this 1st day of October, 1941.
Ara B. Hutchins, Notary Public.
(My commission expires June, 1943.)

Book Reviews

Transactions A. I. M. E. (1941) Volume 142, *Petroleum Development and Technology*. Published by The Institute of Mining and Metallurgical Engineers, 29 West Thirty-Ninth Street, New York, New York. 587 pp. Price $5.00.

This book has six chapters entitled Production Engineering, Engineering Research, Petroleum Economics, Production, Domestic and Foreign, Education, and Refining. It is the sixteenth of the Petroleum Development and Technology series of the Petroleum Division of the A. I. M. E. and contains papers and discussions presented before the Division at New York, February 12-15, 1940; Los Angeles, California, October 17-18, 1940, and Tulsa, Oklahoma, October 24-26, 1940. Also contained in the book are the petroleum statistical reports covering the year 1940.

•

Test Engineers' Handbook, by E. Molloy. Published by Chemical Publishing Company, Inc., Brooklyn, New York. 112 pp. Price $2.00.

Presentation of the principal types of works' tests that are employed in connection with the various branches of engineering work, is made by the author in this book. It deals with the testing of engines, including aero engines, materials, fuels, and lubricating oils.

•

Elementary Mathematics for Engineers, by Sir Ambrose Fleming. Published by the Chemical Publishing Company, Inc., Brooklyn, New York. 110 pp. Price $2.00.

A valuable book for the college engineering student. Although this particular book is designed primarily for the electrical engineer, it contains chapters on algebra, plane trigonometry, plain coördinate geometry, vector algebra, differential calculus, integral calculus, differential equations, harmonic analysis, hyperbolic trigonometry, and mathematical tables. It is written in simple, direct terms that may be easily understood by the student or one interested in reviewing basic mathematical principles.

Emco Executives Called For Military Service

Three executives of the Pittsburgh Equitable Meter Company have recently been called for active military duty in different branches of the service.

COL. W. F. ROCKWELL

Colonel W. F. Rockwell, president of the company, was called for extended active service early in October, reporting to Washington, D.C., where he has been serving as assistant to the chief of the Motor Transport Division.

Captain A. E. Higgins, vice-president of the company, originally called in mid-summer for active duty in the Air Corps, has been temporarily deferred due to certain National Defense activities in which the Pittsburgh firm is engaged.

For the last eight months, Captain J. R. Sproat of the sales staff has been serving with the 176th Field Artillery in command of Battery "F" at Fort Meade.

The Petroleum Engineer *Is Available Through Subscription Only*

IT IS NOT FOR SALE ON THE NEWS STANDS

Emergencies come and emergencies go. In the past thirty years of building carburetors, we have gladly turned on the midnight oil on many occasions. Night shifts have become necessary to meet the demands for more carburetors.

But increased man-hours alone isn't the complete answer. There's the procurement of materials and the allocation of finished products to many industries which calls for a closer cooperation between supplier and producer.

We are getting our shoulder to the wheel. Every facility of our Engineering and Production Departments and the wholehearted cooperation of every employee is utilized to the end that our customers engaged in national defense work are not kept waiting.

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HAVE YOU TRIED THE NEW "TOLEDO" SIMPACT?

—for threading 1" to 2" pipe. High speed steel dies. One set threads four sizes. Instant, positive size change. Oil pockets collect oil which automatically drips on dies and pipe as thread is cut. Simple, easy to operate pipe holder. All self-contained. Order from your local distributor's stock. You will like this new "TOLEDO".

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"TOLEDO"

The PETROLEUM ENGINEER

A MAGAZINE
of
METHODS
for
OPERATING MEN

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Paul H. Jones Heads S. M. Jones Company

At a recent meeting of the board of directors of The S. M. Jones Company, Toledo, Ohio, Paul H. Jones was elected president to succeed his brother, Percy C. Jones, who passed away October 9, 1941, at Beaumont, Texas. Mason B. Jones was elected vice-president and secretary.

Importance of Arc-Welding Symbolized by New Stamp

The tremendous part arc-welding is playing in the war effort of the Union of South Africa has been recognized by the issuance of a special postage stamp. This indicates that the Union is not lagging behind other countries in the use of this

new industrial giant in the construction of her ships, tanks, aircraft, and similar equipment.

The accompanying photograph, supplied by The Lincoln Electric Company, Cleveland, Ohio, shows two of the stamps that are of 6d value. Each stamp is printed both in English, as shown on the right, or Afrikaans, as on the left. This is the case with all stamps issued in South Africa.

The stamp depicts a welder using modern shielded electric-arc equipment and dressed in protective head shield, gloves, and other special clothing.

Lincoln Electric officials say that as far as they know, this is the first time that such a stamp has been issued in the history either of stamps or welding.

R. B. Boand Branch Manager For Union Wire Rope

H. R. Cutlip, district manager of Union Wire Rope Corporation, at Houston, Texas, has announced the appointment of Robert B. Boand as branch manager, effective November 15, with headquarters at their warehouse, 329-33 North Front Street, New Orleans, Louisiana.

R. B. BOAND

Boand has been representing Union in Texas with headquarters at Houston for the last two years, and prior to that time was in main office sales at Kansas City, Missouri, since 1937. Boand is a graduate of Missouri University, and a factory-trained wire rope man.

MEETINGS

California Natural Gasoline Association, Monthly Meeting—December 4, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles.

New Mexico Oil and Gas Association—December 3, Artesia, New Mexico.

American Institute of Electrical Engineers, Southeastern District—December 3, 4, and 5, New Orleans, Louisiana.

Petroleum Electric Power Association, Annual Meeting—December 4 and 5, Baker Hotel, Dallas, Texas.

Oklahoma Stripper Well Association—December 5, Tulsa, Oklahoma.

South Dakota Independent Oil Men's Association, 23rd Annual Convention—December 9 and 10, Hotel Sherman, Aberdeen, South Dakota.

Society of Automotive Engineers, Annual Meeting (and Engineering Display)—January 12, 13, 14, 15, and 16, 1942, Book-Cadillac Hotel, Detroit, Michigan.

American Petroleum Institute, Division of Production, Southwestern District, Spring Meeting—February 26 and 27, 1942, Adolphus Hotel, Dallas, Texas.

North Texas Oil and Gas Association—February 28, 1942, Wichita Falls, Texas.

Indiana Independent Petroleum Association, Spring Convention and Refiners' and Suppliers' Exhibit—March 3, 4, and 5, 1942, Hotel Severin, Indianapolis, Indiana.

Wisconsin Petroleum Association, Annual Convention and Equipment Show—March 18, 19, and 20, 1942, Schroeder Hotel, Milwaukee, Wisconsin.

American Society of Mechanical Engineers, Spring Meeting—March 23, 24, and 25, 1942, Houston, Texas.

American Institute of Mining and Metallurgical Engineers—April 15, 16, and 17, 1942, Cincinnati, Ohio.

National Petroleum Association, Thirty-ninth Semi-Annual Meeting—April 16 and 17, 1942, Hotel Cleveland, Cleveland, Ohio.

Southwestern Gas Measurement Short Course—April 21, 22, and 23, 1942, University of Oklahoma, Norman, Oklahoma.

American Association of Petroleum Geologists, Twenty-seventh Annual Meeting—April 21, 22, 23, and 24, 1942, Cosmopolitan Hotel, Denver, Colorado.

Petroleum Industry Electrical Association—April 22, 23, and 24, 1942, Shreveport, Louisiana.

Natural Gasoline Association of America—May 13, 14, and 15, 1942, Mayo Hotel, Tulsa, Oklahoma.

International Petroleum Exposition—May 16, 17, 18, 19, 20, 21, 22, and 23, 1942, Tulsa, Oklahoma.

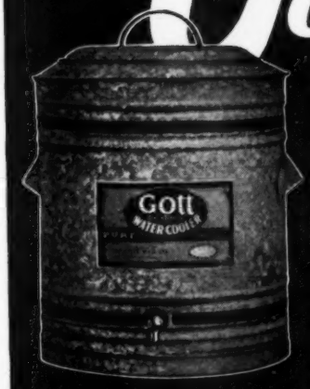
American Society of Mechanical Engineers, Semi-Annual Meeting—June 8, 9, 10, and 11, 1942, Cleveland, Ohio.

American Society of Mechanical Engineers, Fall Meeting—October 12, 13, and 14, 1942, Rochester, New York.

American Petroleum Institute, Annual Meeting—November 9, 1942, Chicago, Illinois.

Gotkool

WATER CANS & COOLERS



GOTT Water Coolers are the convenient way to keep drinking water handy to the worker, protect it from impurities. Their exclusive construction keeps water cool for long periods. Snug fitting large removable top, handy non-leaking push button faucet. GOTT Water Cans for handy field use. Your Supply Store has them, get one today!

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Made in 2, 5, 8, 10, and 20 gallon sizes.

GOTT WATER CAN
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KEEP PURE DRINKING WATER ALWAYS HANDY

A Complete Instrument Service

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CONSTRUCTION
MAINTENANCE

INSTRUMENTS INCORPORATED
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DALLAS

PUT AN END TO LOOSE FASTENINGS . . .

BOLTED CONNECTIONS that work loose are dangerous and expensive. You can avoid them by insisting on Elastic Stop Nuts. Your supply house can furnish them.

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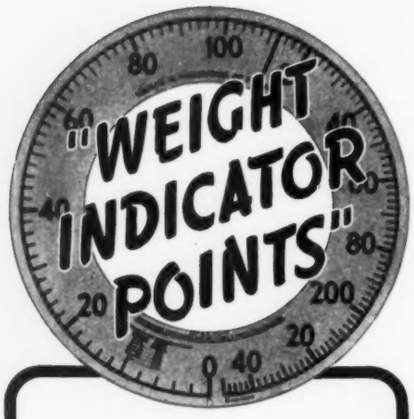

They still haven't found a way to get blood out of a turnip.

So also with drilling instruments that are obsolete or run down at the heels. You simply can't expect them to give the information you need to get the **most** in drilling efficiency . . . the **most** in equipment performance . . . the **most** well per dollar spent.

For portable jobs, toolpusher indicators are mighty satisfactory. But for economy's sake on major drilling jobs, put your drilling control in the hands of the instrument made for the work —the **Martin-Decker "Sealtite," centralized right in front of your driller!**

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